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CHARACTERISTICS OF ECONOMIC GROWTH

THREE ESSAYS

HAIFENG WANG

A thesis submitted for the degree of Doctor of Philosophy

University of Bath

Department of Economics and International Development

October 2005

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To Yingfan and Rongrong

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SUMMARY

Three essays are presented and focus respectively on three separate but related issues after a comprehensive review of the growth literature. The first essay critically examines growth accounting and then investigates the association between the level of TFP, domestic and foreign R&D capital stocks, the overall capital stock, a trend term and openness. Various panel data methods are employed to explore the data generated from 16 selected OECD countries covering the period 1960-1997. The first-stage results, from growth accounting, show that TFP growth is the most important factor to explain GDP growth. The second-stage results, from regressions of TFP on a number of explanatory variables, suggest that the foreign R&D capital stock itself has no immediate benefit to domestic TFP. However foreign R&D capital stock could enhance domestic TFP through trade.

The second essay suggests and empirically investigates three conditional convergence mechanisms with respect to the same OECD data set. We employ the conventional framework of conditional growth convergence to examine in turn the conditional convergence of per capita GDP, per capita capital stock, and TFP. Our results equally support the three suggested conditional convergence mechanisms. However, those convergence mechanisms are reported differently from each other. In particular, no evidence is found to support the theoretical statement that capital stock convergence is equivalent to GDP convergence, while conditional TFP convergence provides solid evidence to support various endogenous growth theories. To some extent, endogeneity tests help to identify the role of each explanatory variable, and hence to shape the properties of the conditional convergence mechanisms.

The third essay reviews the unique story of economic transition in the former Soviet Union and East Europe during 1991-2000, within the framework of conditional growth convergence. To explore the association between economic performance and transition policies indicated by a set of transition indicators, we first distinguish speed from level effects of transition policies and then investigate the data with panel data methods. Surprisingly, we find that negative associations of growth with most of the transition policies are dominant in the sample period. We interpret this in terms of the unexpected massive transition cost.

LIST OF ABBREVIATIONS

2SLS	Two Stage Least Squares
AIC	Akaike Information Criterion
CEE	Central and Eastern Europe
CLI	Cumulative Liberalisation Index
EBRD	European Bank for Reconstruction and Development
EC	European Commission
EU	European Union
GDP	Gross Domestic Product
GLS	Generalised Least Squares
GMM	Generalized Moment Method
GNP	Gross National Product
LM	Lagrange Multiplier
LR	Likelihood Ratio
LSDV	Least Squares Dummy Variables
PPP	Purchasing Power Parity
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Squares
SBC	Schwarz Bayesian Information Criterion
SEE	South Eastern Europe
TFP	Total Factor Productivity

CHAPTER 1

INTRODUCTION

Economic growth has always been one of the central topics in economics. There has accumulated both extensive theoretical developments and rich empirical evidence, much of which can be found in three recent excellent postgraduate textbooks: Economic Growth (2nd edition) (Barro and Sala-i-Martin, 2003), Lectures on Economic Growth (Lucas, 2002) and Endogenous Economic Growth (Aghion and Howitt, 1998).

A number of facts have been stylised in the growth literature. Barro and Sala-i-Martin (2003; 1995) highlight six facts, which were originally suggested by Kaldor (1963), as follows:

- Per capita output and labour productivity grow steadily over time, without sign of a falling rate of growth of productivity;
- Physical capital per worker grows over time regardless of the statistical measure of capital;
- The return to capital remains constant over time in the advanced capitalist economies;
- Capital-output ratios remain steady over long periods;

- There is a steady share of profit in income along with a steady share of investment in output, with a high correlation between the share of profits in income and the share of investment in output;
- Appreciable differences in growth of labour productivity and of aggregate output are observed in different economies.

Lucas (1988; 2002: p19-62) examines Solow's (1956) and particularly Denison's (1961) studies, which are based on the aggregate output of the United States of America during the period 1909-1957, and highlights the facts that American real output grew at an annual rate of 2.9 percent, employed man-hours at 1.3 percent, and capital stock at 2.4 percent. The remarkable character of these facts is that the above figures remain stable over a long period of at least several decades (Lucas 1988; 2002: p23). This can also be found, even in the period of the Great Depression, if business-cycle effects are removed in a reasonable manner, for instance, using the peak-to-peak growth rate (ibid).

However, some of these facts violate marginal productivity theory and capital theory (Lucas, 1998; 2002). In particular, the law of diminishing return to capital, the underlying assumption of neo-classical theory, receives little support. The absence of diminishing returns to capital might be interpreted from two different perspectives. On the one hand, continuous technological progress demands the continuous accumulation of capital stock. The development of endogenous growth theory extensively explores various growth mechanisms based on human capital, research and innovation, and technological spill over. On the other hand, diminishing returns to capital might be obscured by other factors, and might be revealed within a conditional framework.

Based on a critical review of existing literature in chapter two, this thesis explores the role of total factor productivity (TFP), the impact of R&D capital stocks on TFP, the evidence for conditional growth convergence, and the impact of human capital on growth convergence, primarily with data from 16 selected OECD countries for the period of 1960 to 1997. Firstly, we try to reassess the roles of total factor productivity, in economic growth, based on the information presented by conventional growth accounting. Secondly, we employ the framework of conditional growth convergence to investigate respectively the possible existence of conditional capital and technological convergence. Finally, we go further and apply the framework of conditional growth convergence to the transition economies of Eastern Europe and the former Soviet Union to reveal the underlying process of growth in transition.

The three essays contained in this study are all grounded in standard economic growth theories and are comparable with existing empirical evidence. The first one is inspired by the continuing debates on the contribution of factor inputs to growth, in particular, that of total factor productivity (TFP), which is referred to as Solow's residual (Solow, 1956; 1957). TFP is, in most cases, argued to have a significant and substantial contribution to growth, and overwhelming evidence has been accumulated for this. However Young's study of four newly industrialised Asian economies does not strongly support this view (Young, 1995; 1998). In general, growth accounting provides the sole method of comparing the relative contribution of factor inputs to growth.

The weakness of growth accounting is that each economy has to be studied separately and thus the overall picture may be obscured. Some economies may be heavily determined by their unique economic or non-economic characteristics and therefore are not representative. For instance, Singapore is a city-state economy and possibly performs very differently from others. Consequently, few general conclusions can be drawn from such fragmented information.

This first essay contains two studies. The first study is a growth accounting exercise, by which annual TFP growth indices can be generated. Some primary results can be drawn from this conventional assessment of the role of TFP. The second study explores further the determinants of TFP growth, based on the collection of the separate TFP series generated from growth accounting. We will conduct a regression of TFP growth on a number of variables such as a trend term, physical capital, and foreign and domestic R&D capital stocks, as suggested by theories, using panel data methods. A panel data set is established covering 16 selected OECD economies for the period 1960-1997, depending on data availability.

The second essay is motivated by the current empirical development of the idea of conditional growth convergence, which has received overwhelming empirical support. However, the theoretical foundation of the conditional convergence of growth relies primarily on the idea of diminishing returns to capital, which cannot be explicitly observed. Moreover, in neoclassical theory, conditional growth convergence is equivalent to conditional capital convergence. This essay primarily focuses on whether there is empirical evidence for this equivalence, though we then also investigate the determinants of TFP.

Our objectives are twofold. Firstly, we investigate the conditional convergence of the capital stock, following an examination of conditional growth convergence of GDP per capita. Using the data set from 16 selected OECD countries, we try to explore the appropriate models with various test statistics, using panel data approaches. Where capital convergence is observed, different model specifications suggest different determining mechanisms for capital convergence and growth convergence, at least for the sample of counties studied.

Secondly, using a similar framework, the conditional convergence of TFP is further explored. Strong and consistent conditional convergence of TFP is expected, when TFP is supposed to play an important role in driving growth. We suggest several alternative proxies for the level of TFP, which itself cannot be directly estimated, particularly in cross-country analysis. The characteristics of TFP convergence are revealed by the regression results.

Further comparison of the results from the above three kinds of conditional convergence specifications will help to distinguish the differences among them. The same variable can behave differently in the three convergence mechanisms. A simultaneous or endogenous issue might arise, associated with one particular variable or specification. This detailed information will help to illustrate the roles of variables in the three convergence mechanisms.

The third essay examines the transition process of Central and Eastern Europe and the former Soviet Union during 1991-2000, within the framework of conditional growth convergence. We are particularly interested in the association between growth and transition indicators. We distinguish a speed effect from a level effect, for transition indicators, and then investigate their behaviour in our model. The transition variables are examined using both general-to-specific and partial regression approaches and they are designed to deliver information to explain the specific transition process.

The application of conditional growth convergence in the transition literature is intended to allow an empirical comparison between transition economies and market economies. Such a comparison might help us to understand the characteristics of the particular transition process within a standard economic model. If a comparison can be established, it can be argued that the additional information carried by the transition indicators is more plausible.

In summary, these three essays were designed to investigate three different growth issues. The first two essays are theoretically derived from conventional growth theories, but the third explores a unique process within growth theory. All these studies are primarily data driven and panel data methods are used extensively. We hope that they provide new evidence to understand some key characteristics of economic growth.

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction

Neoclassical growth theories sparked by the work of Robert Solow (1956, 1957) have had a profound influence on the empirical studies of economic growth, though there has been a substantial development of endogenous growth theories in the last two decades. To raise further research topics, this chapter critically reviews two aspects of the significance of neoclassical growth theories. The following three chapters will provide new empirical insights into these two topics.

The first topic is the measure of total factor productivity (TFP) associated with growth accounting. Growth accounting was suggested by Solow (1957), substantially extended by Jorgenson and Griliches (1967) and Jorgenson, Gollop and Fraumeni (1987), and recently updated by Barro (1999) and Barro and Sala-i-Martin (2003). It breaks down economic growth into the product of a number of factor inputs, and a residual, TFP, which reflects technological progress and other factors. Most empirical studies acknowledge the significant contribution of TFP, though there is no conclusive agreement.

The second topic is the implication of growth convergence, in particular, conditional growth convergence, which has received a great deal of supportive evidence. Inspired by Solow's pioneering study (1956), Mankiw, Romer, and Weil (1992) developed a theoretical framework to test the Solow model, reveal the feature of growth convergence, and highlight the importance of human capital. However, this framework has been found to be inappropriate to accommodate empirical growth studies (Islam 1995, Caselli, Esquivel, and Lefort 1996). By contrast, a relatively general framework suggested by Barro (1991) and Barro and Sala-i-Martin (1991; 1992) is favoured, and has been widely applied (Caselli, Esquivel, and Lefort 1996).

2.2. Growth accounting

2.2.1. Conventional growth accounting

Solow (1957) presents growth accounting with a Cobb-Douglas production function. He assumes perfect competition, and hence each factor input can receive its marginal product. He also assumes constant returns to scale, which secures the equality between the elasticity of output with respect to a factor's input, and the factor's share in total output. Barro (1999) generalises Solow's growth accounting with a general production function:

$$Y(t) = F(A(t), K(t), L(t)) \tag{1}$$

Y(t) is output, A(t) the level of the technological index, L(t) labour stock, and K(t) capital stock. Differentiating equation (1) with respect to time and then dividing by output Y(t), we can obtain:

$$\begin{aligned} \frac{dY(t)}{Y(t)dt} &= \frac{A(t)\cdot F_{A(t)}}{Y(t)}\cdot\frac{dA(t)}{A(t)dt} \\ &+\frac{K(t)\cdot F_{K(t)}}{Y(t)}\cdot\frac{dK(t)}{K(t)dt}+\frac{L(t)\cdot F_{L(t)}}{Y(t)}\cdot\frac{dL(t)}{L(t)dt} \end{aligned} \tag{2}$$

An alternative expression is:

$$\frac{\dot{Y}(t)}{Y(t)} = \frac{A(t)\cdot F_{A(t)}}{Y(t)}\cdot\frac{\dot{A}(t)}{A(t)} + \frac{K(t)\cdot F_{K(t)}}{Y(t)}\cdot\frac{\dot{K}(t)}{K(t)} + \frac{L(t)\cdot F_{L(t)}}{Y(t)}\cdot\frac{\dot{L}(t)}{L(t)} \tag{3}$$

where $F_{A(t)}$, $F_{K(t)}$, and $F_{L(t)}$ are respectively the marginal products of factors. The growth of technological change, g(t), also known as total factor productivity, is given by:

$$g(t) = \frac{A(t)\cdot F_{A(t)}}{Y(t)}\cdot\frac{dA(t)}{A(t)dt} = \frac{A(t)\cdot F_{A(t)}}{Y(t)}\cdot\frac{\dot{A}(t)}{A(t)} = \frac{\dot{Y}(t)}{Y(t)} - \frac{K(t)\cdot F_{K(t)}}{Y(t)}\cdot\frac{\dot{K}(t)}{K(t)} - \frac{L(t)\cdot F_{L(t)}}{Y(t)}\cdot\frac{\dot{L}(t)}{L(t)} \tag{4}$$

Following the Solow specification associated with a Hicks-neutral production function, equation (4) can be specified as:

$$g(t) = \frac{dA(t)}{A(t)dt} = \frac{\dot{A}(t)}{A(t)} = \frac{\dot{Y}(t)}{Y(t)} - \frac{K(t)\cdot F_{K(t)}}{Y(t)}\cdot\frac{\dot{K}(t)}{K(t)} - \frac{L(t)\cdot F_{L(t)}}{Y(t)}\cdot\frac{\dot{L}(t)}{L(t)} \tag{5}$$

In a perfectly competitive market, each factor receives the value of its marginal product, and hence the elasticity of output with respect to a factor input coincides with the factor's share in total output. Constant returns to scale determine the unity of the summation of all factor shares. As a result, the practical framework of growth accounting is given by:

$$g(t) = \frac{\dot{Y}(t)}{Y(t)} - s_{K(t)}\cdot\frac{\dot{K}(t)}{K(t)} - s_{L(t)}\cdot\frac{\dot{L}(t)}{L(t)} \tag{6}$$

where $s_{K(t)}$ and $s_{L(t)}$ are the factor shares of each input in total output, and $s_{K(T)} = 1 - s_{L(t)}$. Clearly perfect competition and constant returns to scale are essential for this application of growth accounting.

2.2.2. Growth accounting with decomposition of factor inputs

Jorgenson and Griliches (1967) emphasise the importance of decomposing the factor inputs into a number of quality categories. This was further extended by Jorgenson, Gollop and Fraumeni (1987). Growth accounting at the aggregate level relies on the fundamental identity that the value of output is equal to the sum of the value of total factor inputs (Jorgenson and Griliches, 1967; Jorgenson, Gollop and Fraumeni, 1987). It is developed based on value-added production functions for all sectors. It assumes market equilibrium between supply and demand. Following Jorgenson and Griliches (1967) and Jorgenson, Gollop and Fraumeni (1987), suppose there are n sectors, p capital goods, and q labour inputs in an economy. The supplies of each capital goods and labour input are given by:

$$K_k = \sum_i K_{ki} \qquad (k = 1, 2, \ldots, p;\ i = 1, 2, \ldots, n) \qquad (7)$$

$$L_l = \sum_i L_{li} \qquad (l = 1, 2, \ldots, p;\ i = 1, 2, \ldots, n) \qquad (8)$$

where K_k is the total input of capital goods, k, and L_l is the total input of labour l.

The production possibility frontier for the economy is given by the level of aggregate output, which for simplicity is normalised at unity without loss of generality:

$$H(Y_1, Y_2, \ldots, Y_n; K_1, K_2, \ldots, K_p; L_1, L_2, \ldots, L_q; T) = 1 \qquad (9)$$

where Y_1 , Y_2 ,..., Y_n are value-added for each sector, and T is a time variable. The shares of value-added for all sectors, capital goods, and labour inputs in aggregate value added are given by:

$$s_i^Y = \frac{p_Y^i Y_i}{\sum p_Y^i Y_i} = \frac{d \ln H(Y_1, Y_2, ..., Y_n; K_1, K_2, ..., K_p; L_1, L_2, ..., L_q; T)}{d \ln Y_i}$$

$$(i = 1, 2, ..., n) \qquad (10)$$

$$s_k^K = \frac{p_K^k K_k}{\sum p_K^k K_{ki}} = \frac{d \ln H(Y_1, Y_2, ..., Y_n; K_1, K_2, ..., K_p; L_1, L_2, ..., L_q; T)}{d \ln K_k}$$

$$(k = 1, 2, ..., p) \qquad (11)$$

$$s_l^L = \frac{p_L^l L_l}{\sum p_L^l L_l} = \frac{d \ln H(Y_1, Y_2, ..., Y_n; K_1, K_2, ..., K_p; L_1, L_2, ..., L_q; T)}{d \ln L_l}$$

$$(l = 1, 2, ..., q) \qquad (12)$$

where $p^i{}_Y$, $p^k{}_K$, *and* $p^l{}_L$ are respectively the prices of value-added, capital goods, and labour inputs. These shares, under perfectly competitive market conditions and equilibrium, are equal to the elasticities of aggregate output with respect to the quantities of value-added and factor inputs. As constant returns to scale are assumed, both the shares of value-added for all sectors and the shares of all factor inputs sum to unity. The productivity growth for the whole economy is given by:

$$g_T = \frac{d \ln H(Y_1, Y_2, ..., Y_n; K_1, K_2, ..., K_p; L_1, L_2, ..., L_q; T)}{dT} \qquad (13)$$

Alternatively, the production possibility frontier can be replaced by a production function associated with factor inputs. The corresponding value-added aggregate production function with constant returns to scale is defined as:

$$Y = F(K, L, T) \qquad (14)$$

where the capital and labour inputs are functions of their components:

$$K = K(K_1, K_2, ..., K_p) \qquad (15)$$

$$L = L(L_1, L_2, ..., L_q) \quad (16)$$

The existence of an aggregate production function implies that the value added function of each sector is identical up to a scalar multiple, c_i,

$$Y_i = c_i \cdot F(K_i, L_i, T) \qquad (i = 1, 2, ..., n) \quad (17)$$

Appropriate choice of dimensions for measuring value-added in each sector can result in all value added functions being identical to the aggregate production function (14). The market condition implies that the value share of each factor input is equal to the elasticity of output with respect to that input, and hence we have:

$$s^K = \frac{p_K K}{p_Y Y} = \frac{d \ln Y(K, L, T)}{d \ln K} \quad (18)$$

$$s^L = \frac{p_L L}{p_Y Y} = \frac{d \ln Y(K, L, T)}{d \ln L} \quad (19)$$

Similarly, the shares of components of capital goods and labour inputs are equal to the elasticities of the corresponding aggregate with respect to those inputs:

$$s_k^K = \frac{p_K^k K_k}{\sum p_K^k K_k} = \frac{d \ln K(K_1, K_2, ..., K_p)}{d \ln K_k} \qquad (k = 1, 2, ..., p) \quad (20)$$

$$s_l^L = \frac{p_L^l L_l}{\sum p_L^l L_l} = \frac{d \ln Y(L_1, L_2, ..., L_q)}{d \ln L_l} \qquad (l = 1, 2, ..., q) \quad (21)$$

If the production function is homogeneous of degree one in factor inputs, *K* and *L*, constant returns to scale are satisfied. In addition, productivity growth is assumed to be Hicks neutral, and thus independent of capital goods and labour inputs. It depends only on time. Therefore, we get:

$$g_T = \frac{d \ln F(K,L,T)}{dT} = \frac{d \ln F(A(T);K,L)}{dT} = \frac{d \ln A(T)}{dT} \tag{22}$$

Clearly, the theory of growth accounting presented here is based on quantity indices of productivity, capital goods, and labour inputs. Analogously, the corresponding price indices will result in a dual to the aggregate production model. The dual is based on the price possibility frontier, where the price of output is a function of the prices of value-added in all sectors, the prices of factor inputs, and time (Jorgenson, Gollop and Fraumeni, 1987: p57-63).

Given the definitions of output and factor input, the sum of value-added in all sectors is equal to the sum of capital goods and labour inputs in all sectors. This accounting identity for the economy is given by:

$$\sum p_Y^i Y_i = \sum p_K^k K_k + \sum p_L^l L_l \tag{23}$$

The accounting identity implies that there are equivalent measures of productivity growth based on the dual relation between quantities and prices (Jorgenson, Gollop and Fraumeni 1987; Christensen, Cummings and Jorgensen 1980; 1981; Hsieh 1999; 2002; Barro 1999; and Barro and Sala-i-Martin 2003).

Wallace E. Huffman and Robert E. Evenson (1993) show there are equivalent measures of productivity growth based on the dual relationship between production, cost and profit functions. They suggest that agricultural productivity can be further explained by a number of determining variables such as R&D, agricultural extension services, and farmer education. This is referred to as "two-stage decomposition analysis" (Huffman and Evenson 1992; 1993; Colin Thirtle and Paul Bottomley 1992). In the first stage, agricultural productivity - a TFP index - is calculated from a growth accounting approach. This is a level index. The second stage contains regressions of the TFP index on a number of explanatory variables.

Jorgenson, Gollop and Fraumeni (1987) specify a translog value-added production function that is widely used in empirical work.

$$Y = F(K,L,T) = \exp\begin{pmatrix} \alpha_0 + \alpha_K \ln K + \alpha_L \ln L + \alpha_T \cdot T \\ + \beta_{KL} \ln K \ln L + \beta_{KT} \ln K \cdot T + \beta_{LT} \ln L \cdot T \\ + \frac{1}{2}\beta_{KK}(\ln K)^2 + \frac{1}{2}\beta_{LL}(\ln L)^2 + \frac{1}{2}\beta_{TT} \cdot T^2 \end{pmatrix} \quad (24)$$

All the sectoral value-added functions are identical to the aggregate production function. The market condition allows each factor input to receive its marginal product, and hence the share of each factor is equal to the elasticity of output with respect to that factor. We get:

$$s_K = \alpha_K + \beta_{KK} \ln K + \beta_{KL} \ln L + \beta_{KT} \cdot T \quad (25)$$

$$s_L = \alpha_L + \beta_{LL} \ln L + \beta_{KL} \ln K + \beta_{LT} \cdot T \quad (26)$$

$$g_T = \alpha_T + \beta_{KT} \ln K + \beta_{LT} \ln L + \beta_{TT} \cdot T \quad (27)$$

The translog production function satisfies constant returns to scale if and only if the parameters in equation (24) meet the conditions (28) – (31):

$$\alpha_K + \alpha_L = 1 \quad (28)$$

$$\beta_{LL} + \beta_{KL} = 0 \quad (29)$$

$$\beta_{KK} + \beta_{KL} = 0 \quad (30)$$

$$\beta_{KT} + \beta_{LT} = 0 \quad (31)$$

For two successive periods T-1, and T, the growth rate of output can be expressed as a weighted average of factors' growth and productivity growth:

$$\ln\frac{Y(T)}{Y(T-1)} = \bar{s}_K \ln\frac{K(T)}{K(T-1)} + \bar{s}_L \ln\frac{L(T)}{L(T-1)} + \bar{g}_T \quad (32)$$

where weights are the averages of the corresponding factor shares:

$$\bar{s}_K = \frac{1}{2}[s_K(T-1) + s_K(T)] \tag{33}$$

$$\bar{s}_L = \frac{1}{2}[s_L(T-1) + s_L(T)] \tag{34}$$

$$\bar{g}_T = \frac{1}{2}[g_T(T-1) + g_T(t)] \tag{35}$$

Jorgenson, Gollop and Fraumeni (1987) refer to the average rate of productivity growth, $\bar{g}_T$ as the translog index of the rate of productivity growth. Clearly it is an empirical representative of the Solow residual, also known as TFP in the literature. Rearranging equation (32), we get an explicit expression for the rate of productivity growth:

$$\bar{g}_T = \ln\frac{Y(T)}{Y(T-1)} - \bar{s}_K \ln\frac{K(T)}{K(T-1)} - \bar{s}_L \ln\frac{L(T)}{L(T-1)} \tag{36}$$

Similarly, the translog specifications are also applied to the production functions of capital goods and labour inputs. The two conditions – a perfectly competitive market and constant returns to scale - are retained throughout.

The aggregate model of production for the whole economy is derived from a multisectoral value-added production function model for all sectors. The aggregate model can be based on a production possibility frontier and conditions for producer equilibrium (Jorgenson, Gollop and Fraumeni, 1987). The alternative is an aggregate production function, which requires that all sectoral value added functions are identical and that factor inputs within each sector are also identical functions of their components.

Following Jorgenson, Gollop and Fraumeni (1987), we define the price of aggregate value-added, p_Y, in terms of the prices of value-added in all sectors, p_Y^i:

$$p_Y Y = p_Y \sum Y_i = \sum p_Y^i Y_i \tag{37}$$

Equation (37) is identified as another accounting identity (Jorgenson, Gollop and Fraumeni, 1987). Analogously, other accounting identities for capital goods and labour inputs are defined as:

$$p_K^k K_k = p_K^k \sum K_k^i = \sum p_K^{k\,i} K_k^i \qquad (k = 1, 2, \ldots, p) \tag{38}$$

$$p_L^l L_l = p_L^l \sum L_l^i = \sum p_L^{l\,i} L_l^i \qquad (l = 1, 2, \ldots, q) \tag{39}$$

Substituting equations (37), (38), and (39) into equation (36), we have the rate of productivity growth for the whole economy as:

$$\begin{aligned} \bar{g}_T &= \ln\frac{Y(T)}{Y(T-1)} - \bar{s}_K \sum_{k=1}^{p}\left(\bar{s}_K^k \ln\frac{K_k(T)}{K_k(T-1)}\right) \\ &- \bar{s}_L \sum_{l=1}^{q}\left(\bar{s}_L^l \ln\frac{L_l(T)}{L_l(T-1)}\right) \end{aligned} \tag{40}$$

In contrast, the rate of productivity growth for each sector can be written as:

$$\begin{aligned} \bar{g}_T^i &= \bar{s}_Y^i \ln\frac{Y^i(T)}{Y^i(T-1)} - \bar{s}_K^i \sum_{k=1}^{p}\left(\bar{s}_K^{k\,i} \ln\frac{K_k^i(T)}{K_k^i(T-1)}\right) \\ &- \bar{s}_L^i \sum_{l=1}^{q}\left(\bar{s}_L^{l\,i} \ln\frac{L_l^i(T)}{L_l^i(T-1)}\right) \end{aligned} \qquad (i = 1, 2, \ldots, n) \tag{41}$$

where $\bar{s}_Y^i$ is the average value share of value-added in sector i, in which the gross output is a function of intermediate inputs, capital goods, labour inputs, and time. For more detailed discussions about the role of intermediate goods, see Jorgenson, Gollop and Fraumeni (1987: p32-53).

Finally, multiplying the sectoral rates of productivity growth by the share of value added in that sector to value–added in all sectors, summing over all sectors, and subtracting the results from the rate of productivity growth for the entire economy, we have:

$$\bar{g}_T = \sum_i \frac{\bar{s}_i}{\bar{s}_Y^i} \cdot \bar{g}_T^i + \ln\frac{Y(T)}{Y(T-1)} - \sum_i \bar{s}_i \frac{\ln Y_i(T)}{\ln Y_i(T-1)}$$
$$+ \sum_i \bar{s}_i \cdot \frac{\bar{s}_K^i}{\bar{s}_Y^i} \sum_{k=1}^{p} \left(\bar{s}_K^{k\,i} \ln\frac{K_k^i(T)}{K_k^i(T-1)} \right) - \bar{s}_K \cdot \sum_{k=1}^{p} \bar{s}_K^k \cdot \frac{\ln K_k(T)}{\ln K_k(T-1)} \qquad (42)$$
$$+ \sum_i \bar{s}_i \cdot \frac{\bar{s}_L^i}{\bar{s}_Y^i} \sum_{l=1}^{q} \left(\bar{s}_L^{l\,i} \ln\frac{L_l^i(T)}{L_l^i(T-1)} \right) - \bar{s}_L \cdot \sum_{l=1}^{q} \bar{s}_L^l \cdot \frac{\ln L_l(T)}{\ln L_l(T-1)}$$

where the share of value added in that sector to value–added in all sectors is given by:

$$s_i = s_i^Y = \frac{p_Y^i Y_i}{\sum p_Y^i Y_i} \qquad (i = 1, 2, ..., n) \qquad (43)$$

$$\bar{s}_i = \frac{1}{2}[s_i(T-1) + s_i(T)] \qquad (i = 1, 2, ..., n) \qquad (44)$$

Equation (42) presents a comprehensive framework of growth accounting of productivity growth based on a very detailed complete disaggregation of both sector outputs and factor inputs. The first term is a weighted sum of sectoral productivity growth rates and this sum exceeds unity (ibid: p67). The remaining terms reflect the contributions of changes in the cross-sectoral distribution of value-added, all capital goods, and all labour inputs to the aggregate productivity growth.

The methodology presented here demonstrates to what extent the national aggregate productivity growth can be explored based on growth accounting. Jorgenson and Griliches (1967) disaggregate the USA's capital goods into land, residential and non-residential structures, equipment and inventories. They also break down the USA's labour inputs by the male school years completed. Their study shows that productivity growth in USA is less important when the factor inputs are decomposed. Jorgenson, Gollop and Fraumeni (1987) exhaustively extend this method to account for the USA's industrial sectors associated with a number of capital goods and labour inputs. They conclude that the contribution of capital input and labour input is greater than that of productivity growth in most years between 1949 and 1979. Edward Denison (1962; 1974; 1985) has provided similar work on the US growth, for different periods.

However in practice, this methodology demands a great deal of information that is not available for most countries. This review has failed to find similar empirical work conducted outside of the USA, though Christensen, Cummings and Jorgensen (1980; 1981) have to some extent addressed the issue of quality change in capital and labour inputs. In contrast, most empirical studies employ the simple version of the translog framework – equation (36), reproduced below as equation (45) – to explore cross-country differenced in productivity growth (Christensen, Cummings and Jorgensen 1980; 1981; Young 1995; Hsieh 1999; 2002; Barro 1999; Easterly and Levine 2001; Jorgenson and Yip 2001; and Barro and Sala-i-Martin 2003).

$$\bar{g}_T = \ln\frac{Y(T)}{Y(T-1)} - \bar{s}_K \ln\frac{K(T)}{K(T-1)} - \bar{s}_L \ln\frac{L(T)}{L(T-1)} \tag{45}$$

2.2.3. Recent theoretical advances in growth accounting

Barro (1999) and Barro and Sala-i-Martin (2003: 441-460) have extended the theory of growth accounting by integrating a number of factors, such as human capital, technological spillover, and research and development. Their exploration is based on a series of modifications to the production functions, which follow a number of growth theories. This provides a great insight into the theoretical expansion of growth accounting. However it does not provide practical suggestions for empirical applications, mainly due to restrictions on data availability.

2.2.3.1 Growth accounting with increasing returns

Following Griliches (1979), Romer (1986) and Lucas (1988), Barro (1999) reproduced a modified production function, containing a term reflecting an externality that can be interpreted in different ways.

$$Y_i = AL_i^{1-\alpha} K_i^{\alpha} K^{\beta} \qquad 0 < \alpha < 1 \qquad \beta > 0 \qquad (i=1, 2, \ldots, N) \qquad (46)$$

where the production function applies to identical firms *i*. L_i is the standard labour input. Griliches (1979) defines K_i as firm's specific knowledge capital, and K - the sum of the K_i - is the aggregate level of knowledge in a sector. This implies that any firm can automatically benefit from the technological spillover across that sector. Romer (1986) defines K_i as the standard capital goods, and K is the aggregate stock of capital goods in the whole economy. This implies that any firm benefits from learning by investing, via accumulated investment in the whole economy. Lucas (1988) defines K_i as human capital, and K is the aggregate human capital stock for the whole economy. This implies that any firm benefits from accumulation of human capital in the entire economy. To sum up, K reflects the aggregate level of non-rival capital stock, which is beneficial to each firm without additional cost.

For simplicity, following Romer's definition we have:

$$K = \sum K_i \qquad (47)$$

Assuming that each factor input receives its marginal products, constant returns to scale for private factor inputs implies that the share of factor input is equal to the elasticity of the output with respect to that factor input. Therefore, we obtain:

$$\alpha = s_K = 1 - s_L \qquad (48)$$

Assuming that the private capital-labour ratio is identical for each firm, we have:

$$k_i = \frac{K_i}{L_i} = \frac{\sum K_i}{\sum L_i} = \frac{K}{L} = k \tag{49}$$

Now equation (46) can be rewritten as:

$$Y_i = AL_i k_i^{\alpha} k^{\beta} L^{\beta} = AL_i k^{\alpha+\beta} L^{\beta} \tag{50}$$

Aggregating over all identical firms, finally we get:

$$\begin{aligned} Y &= \sum Y_i = \sum AL_i k^{\alpha+\beta} L^{\beta} = Ak^{\alpha+\beta} L^{\beta} \sum L_i \\ &= Ak^{\alpha+\beta} L^{\beta+1} = AK^{\alpha+\beta} L^{1-\alpha} \end{aligned} \tag{51}$$

If the technological spillover is expected to be beneficial to each firm, we have $\beta > 0$. This implies increasing returns to scale after the externality is internalised. We can rewrite the final part of equation (51) in a framework of growth accounting:

$$g^E = \frac{\dot{A}}{A} = \frac{\dot{Y}}{Y} - (\alpha + \beta) \cdot \frac{\dot{K}}{K} - (1 - \alpha) \cdot \frac{\dot{L}}{L} \tag{52}$$

This is different from the framework of standard growth accounting. The elasticity of capital stock to output is higher than its conventional income share, despite that the elasticity of labour remains unchanged. The practical difficulty with equation (52) is that we cannot directly estimate or infer the parameter β (Barro, 1999).

It is easy to establish a connection between equation (52) and standard growth accounting. The TFP growth calculated from the standard growth accounting approach indeed contains precisely the contribution due to the externality specified in the model. This can be seen if we rearrange equation (52):

$$\frac{\dot{A}}{A} - \beta \cdot \frac{\dot{K}}{K} = \frac{\dot{Y}}{Y} - \alpha \cdot \frac{\dot{K}}{K} - (1 - \alpha) \cdot \frac{\dot{L}}{L} = g \tag{53}$$

An empirical implication of the development of equation (53) is to explore the externality effect by regressing the Solow TFP on the capital stock growth rates, if one could get the data. However, this method likely suffers from a simultaneity problem due to the endogeneity of capital stock growth by the construction of TFP growth (ibid).

2.2.3.2 Growth accounting including Research and Development (R&D)

Barro (1999) suggests that growth accounting can also incorporate a term reflecting R&D into its framework. This helps to sketch the key relationship between the TFP and R&D, which is one of the main interests of endogenous growth theories. Two types of models are examined following Barro (1999) and Barro and Sala-i-Martin (2003: 441-460).

2.2.3.2.1 Growth accounting with varieties models

Following Romer (1990) and Grossman and Helpman (1991, ch.3), Barro (1999) starts with a modified production function, which reflects the horizontal expansion of the product-varieties of intermediate capital goods.

$$Y = AL^{1-\alpha}\sum_{i=1}^{N} x_i^{\alpha} \qquad 0<\alpha<1 \qquad (54)$$

where L is labour input, x_i is the intermediate capital goods of type i. N is the total number of varieties of intermediate goods, and Y is gross instead of net output. Y can be used as intermediate inputs to production, or directly allocated to R&D.

In equilibrium, each intermediate good is used at the same quantity, x, and hence:

$$x = x_i = \frac{1}{N}\sum_{i=1}^{N} x_i = \frac{X}{N} \qquad (55)$$

where X is the sum of intermediate goods. X is the flow of services from the aggregate capital stock if all x_i are non-durable goods. Equation (54) can be rewritten as:

$$Y = AL^{1-\alpha} N^{1-\alpha} X^{\alpha} \tag{56}$$

It implies that technological progress can result from R&D expenditure over varieties of intermediate goods. Given that the variable N reflects the current level of technology, the leading technology encompasses all N varieties of intermediate goods available. This model is thus the best for general technologies (David 1991; Bresnahan and Trajtenberg, 1995; and Barro, 1999). Assuming that both labour and intermediate capital goods receive their marginal products, the elasticity of factor input coincides with its input share.

$$\alpha = s_X = 1 - s_L \tag{57}$$

The framework of growth accounting is given as:

$$g^{R\&D} = \frac{\dot{A}}{A} = \frac{\dot{Y}}{Y} - \alpha \cdot \frac{\dot{X}}{X} - (1-\alpha) \cdot \frac{\dot{L}}{L} - (1-\alpha) \cdot \frac{\dot{N}}{N} \tag{58}$$

A link between equation (58) and the standard TFP progress can be established by rearranging the above equation:

$$\frac{\dot{A}}{A} + (1-\alpha) \cdot \frac{\dot{N}}{N} = \frac{\dot{Y}}{Y} - \alpha \cdot \frac{\dot{X}}{X} - (1-\alpha) \cdot \frac{\dot{L}}{L} = g \tag{59}$$

Clearly, the Solow TFP contains the joint contributions of productivity growth from the conventional exogenous technological change and endogenous expansion of varieties. If the expansion of N is proportional to output due to R&D expenditure, the expansion rate of N is governed by:

$$\frac{\dot{N}}{N} = \frac{C^{R\&D}}{\eta N} \qquad (60)$$

where $C^{R\&D}$ is R&D expenditure to increase N, the number of varieties of intermediate goods, and η is a cost parameter denoting the R&D expenditure needed to expand by a single unit of N. Therefore ηN represents the capital stock of all past R&D expenditures. Equation (59) can be rewritten as:

$$g = \frac{\dot{A}}{A} + (1-\alpha)\cdot\frac{C^{R\&D}}{\eta N} \qquad (61)$$

where $C^{R\&D}$ can be approximated by the current flow of R&D and ηN by the market value of accumulated R&D. Griliches (1973) had estimated the effect of an R&D variable on TFP (Barro 1999; Barro and Sala-i-Martin 2003). Equation (58) seems to provide a growth accounting framework to estimate the modified Solow residual, $g^{R\&D}$. However it also requires information on the current R&D expenditure as well as the accumulated capital stock of R&D. In addition, it is also restricted by a number of assumptions, which are unlikely to be satisfied (ibid).

2.2.3.2.2 Growth accounting with quality-ladders models

Following Aghion and Howitt (1992) and Grossman and Helpman (1991, ch.4), Barro (1999) examines the implication of the quality-ladders specification with a modified production function, which reflects the vertical improvements in the quality of intermediate goods.

$$Y = AL^{1-\alpha}\sum_{i=1}^{N}(q_{k_i}x_{ik_i})^{\alpha} \qquad 0<\alpha<1 \qquad (62)$$

where L is labour input, x_i is the intermediate capital goods of type i. N is the fixed number of varieties of intermediate goods. The parameter q > 1 is the proportionate spanning between rungs on a quality ladder. Technological progress can be achieved by R&D expenditure helping to move up the ladder step by step. k_i is the highest rung presently obtained in sector i. x_{iki} is the quantity used of the *i*th kind of non-durable intermediate good.

The main idea of this model is that different quality rungs of intermediate goods in a given sector are assumed to be perfect substitutes (Barro 1999; Barro and Sala-i-Martin 2003: p454). Higher-rung goods are better then lower-rung ones, which are rapidly driven out of the market due to creative destruction. Therefore in equilibrium, the lower-rung goods are always replaced. Equation (62) can be rewritten by aggregation of x_{iki} and q_{ki}:

$$Y = AL^{1-\alpha}Q^{1-\alpha}X^{\alpha} \tag{63}$$

where X is the sum of intermediate goods and Q is an aggregate quality index.

$$X = \sum_{i=1}^{N} x_{ik_i} \tag{64}$$

$$Q = \sum_{i=1}^{N} (q_{k_i})^{\frac{\alpha}{1-\alpha}} \tag{65}$$

Assuming that both labour and intermediate capital goods receive their marginal products, and hence the elasticity of factor input coincides with its input share:

$$\alpha = s_X = 1 - s_L \tag{66}$$

The framework of growth accounting is given as:

$$g^{R\&D} = \frac{\dot{A}}{A} = \frac{\dot{Y}}{Y} - \alpha \cdot \frac{\dot{X}}{X} - (1-\alpha) \cdot \frac{\dot{L}}{L} - (1-\alpha) \cdot \frac{\dot{Q}}{Q} \tag{67}$$

Analogous to the previous section, a connection between equation (67) and the standard TFP progress can be established by rearranging the above equation:

$$\frac{\dot{A}}{A}+(1-\alpha)\cdot\frac{\dot{Q}}{Q}=\frac{\dot{Y}}{Y}-\alpha\cdot\frac{\dot{X}}{X}-(1-\alpha)\cdot\frac{\dot{L}}{L}=g \tag{68}$$

Again the Solow TFP contains the joint contributions of productivity growth from the conventional exogenous technological change and endogenous improvements of intermediate goods along the quality-ladder. If the improvement of Q is proportional to aggregate R&D expenditure, the change rate of Q is governed by:

$$\frac{\dot{Q}}{Q}=\psi\frac{C^{R\&D}}{K^{R\&D}} \tag{69}$$

where $C^{R\&D}$ is current R&D expenditure and $K^{R\&D}$ represents the capital stock of all past R&D expenditures. $0 < \psi < 1$ is a parameter representing the degree of the creative destruction process. A higher ψ indicates more creation than destruction, and hence the contribution of current R&D expenditure to the overall quality index is smaller. Substituting equation (69) into (68), we get:

$$g=\frac{\dot{A}}{A}+\psi(1-\alpha)\cdot\frac{C^{R\&D}}{K^{R\&D}} \tag{70}$$

where $C^{R\&D}$ can be approximated by the current flow of R&D, and $K^{R\&D}$ by the market value of accumulated R&D. Barro (1999) warns that the capital stock of intermediate goods, $K^{R\&D}$, in this particular case, cannot be constructed by the conventional practice, for the capital depreciation rate is zero due to the creative destruction. Therefore, equation (70) cannot provide an empirical framework of growth accounting to estimate the modified Solow residual. In addition, it is difficult to estimate coefficient ψ even if we could establish the capital stock of R&D.

2.2.4 Empirical studies and concluding remarks

There are significant developments of growth accounting in the literature. However, for cross-country investigations most empirical studies have to narrowly follow the simple translog accounting framework – equation (45), primarily due to restrictions on data availability. The only exception is the detailed growth accounting studies of the USA, which have been well documented by Edward Denison (1962; 1974; 1985) and Jorgenson, Gollop and Fraumeni (1987).

Table 2.1 presents two sets of documented growth accounting for several selected major OECD countries for different periods (Barro and Sala-i-Martin 2003; Jorgensen and Yip 2001; and Christensen, Cummings and Jorgensen 1980; 1981). The results show that TFP growth generally plays an important role in explaining GDP growth. By contrast, the contribution of labour growth is smaller than those of capital or TFP growth. The large contribution from TFP likely reflects the bulk of unexplained factors such as the quality of factor inputs, human capital, and research and development, which are very difficult to account for, for whole economies.

Christensen, Cummings and Jorgensen 1980; 1981) have, to some extents, addressed the issues of quality changes in capital and labor input for an international comparison of TFP. They found that the quality change for both capital and labor input during the sample period is positive for the countries except Germany. However, their studies do not support the results reported by Jorgenson and Griliches (1967) and Jorgenson, Gollop and Fraumeni (1987), who show that productivity growth is less important when the factor inputs are decomposed.

TABLE 2.1

GROWTH ACCOUNTING FOR SELECTED OECD COUNTRIES

Country (Period)	Growth Rate of GDP	Contribution from capital growth	Contribution from Labour growth	TFP growth
		Panel A		
Canada (1947-73)	0.0517 (100%)	0.0254 (49%)	0.0088 (17%)	0.0175 (34%)
France (1950-73)	0.542 (100%)	0.0225 (42%)	0.0021 (4%)	0.0296 (54%)
Germany (1952-73)	0.0661 (100%)	0.0269 (41%)	0.0018 (3%)	0.0374 (56%)
Italy (1952-73)	0.0527 (100%)	0.0180 (34%)	0.0011 (2%)	0.0337 (64%)
Japan (1952-73)	0.0951 (100%)	0.0328 (35%)	0.0221 (23%)	0.0402 (42%)
Netherlands (1951-73)	0.0536 (100%)	0.0247 (46%)	0.0042 (8%)	0.0248 (46%)
UK (1955-73)	0.0373 (100%)	0.0176 (47%)	0.0003 (1%)	0.0193 (52%)
USA (1947-73)	0.0402 (100%)	0.0171 (43%)	0.0095 (24%)	0.0135 (34%)
Average		0.0231 (42%)	0.0062 (10%)	0.027 (48%)
		Panel B		
Canada (1960-1995)	0.0369 (100%)	0.0186 (51%)	0.0123 (33%)	0.0057 (16%)
France (1960-1995)	0.0358 (100%)	0.0180 (53%)	0.0033 (10%)	0.0130 (58%)
Germany (1960-1995)	0.0312 (100%)	0.0177 (56%)	0.0014 (4%)	0.0132 (42%)
Italy (1960-1995)	0.0357 (100%)	0.0182 (51%)	0.0035 (9%)	0.0153 (42%)
Japan (1960-1995)	0.0566 (100%)	0.0178 (31%)	0.0125 (22%)	0.0265 (47%)
UK (1960-1995)	0.0318 (100%)	0.0124 (56%)	0.0017 (8%)	0.0080 (36%)
USA (1960-1995)	0.0221 (100%)	0.0117 (37%)	0.0127 (40%)	0.0076 (24%)
Average		0.0163 (48%)	0.0068 (18%)	0.0128 (38%)

Sources: the results are reproduced from Barro and Sala-i-Martin (2003: table 10.1). Panel A is originally from Christensen, Cummings and Jorgensen (1980) and Panel B from Jorgensen and Yip (2001).

The numbers in parentheses for columns three to five is the percentage of the GDP growth rate explained by the corresponding factor and TFP growth.

Alternatively Jones (1997) suggests a growth accounting investigation using a variance decomposition approach. The idea is grounded in the Solow framework of growth accounting given by equation (45):

$$\bar{g}_T = \ln\frac{Y(T)}{Y(T-1)} - \bar{s}_K \ln\frac{K(T)}{K(T-1)} - \bar{s}_L \ln\frac{L(T)}{L(T-1)} \tag{71}$$

Rearranging it in terms of per effective labour unit, we get:

$$\ln\frac{Y(T)/L(T)}{Y(T-1)/L(T-1)} = \bar{s}_K \ln\frac{K(T)/L(T)}{K(T-1)/L(T-1)} + \bar{g}_T \tag{72}$$

for simplicity,

$$\ln\frac{\hat{Y}(T)}{\hat{Y}(T-1)} = \bar{s}_K \ln\frac{\hat{K}(T)}{\hat{K}(T-1)} + \bar{g}_T \tag{73}$$

where

$$\hat{Y}(T) = \frac{Y(T)}{L(T)} \tag{74}$$

$$\hat{K}(T) = \frac{K(T)}{(T)} \tag{75}$$

Assume the factor elasticity is homogenously identified, i.e.

$$\alpha = \bar{s}_K \tag{76}$$

Then for a number of countries in a cross-country analysis, the variance of GDP per effective labour – the left-hand side of equation (72) – can be decomposed into two variances and one covariance:

$$\begin{aligned} Var\left(\ln\frac{\hat{Y}(T)}{\hat{Y}(T-1)}\right) &= Var(\bar{g}_T) + (\bar{s}_K)^2 \cdot Var\left(\ln\frac{\hat{K}(T)}{\hat{K}(T-1)}\right) \\ &+ 2\bar{s}_K \cdot Cov\left(\bar{g}_T, \ln\frac{\hat{K}(T)}{\hat{K}(T-1)}\right) \end{aligned} \tag{77}$$

A comparison of the values of the three components on the right-hand side of equation (77) suggests the relative importance of each factor. Easterly and Levine (2001) use this approach to examine a data set of 60 non-oil economies for two periods 1960-92 and 1980-92. They show that cross-country variation of TFP growth accounts for respectively 58 percent and 65 percent of output growth. They also show that incorporation of human capital does not alter the basic results – TFP growth accounts for the bulk of cross-country growth difference.

The significance of growth accounting is the provision of the information about the unobservable TFP growth indices, known as Solow's residual. This is the first step for the further investigation of TFP. Given the significance of TFP growth suggested in the literature, it is reasonable to suggest further regression of TFP growth on a number of explanatory variables. The recent theoretical extension of growth accounting implies that productivity growth can be further explained by a number of variables such as capital stock, exogenous technological progress, and investment in research and development, although simultaneity problems might occur (Barro 1999; Barro and Sala-i-Martin 2003).

Griliches (1973) was probably the first to suggest such a study by estimating the effect of R&D on TFP. After calculating TFP indices by a growth accounting approach, he suggests a regression of the TFP indices on R&D expenditures and a trend term. The R&D expenditure is expressed as a ratio of the R&D expenditure to total output. The trend term captures the exogenous technical progress. The coefficient of the R&D variable is interpreted as the rate of return to R&D. A number of studies have been implemented following this method (Griliches and Lichtenberg 1984; Griliches 1986; 1988; 1994), though there is concern about the poor quality of the data on R&D (Barro and Sala-i-Martin 2003: p453).

More recent studies focus on investigating the elasticity of the TFP with respect to two types of R&D (Coe and Helpman 1995; Keller 1998; Kao, Chiang and Chen 1999; and Edmond 2001). They are initiated by a growth accounting of the level of TFP rather than TFP growth. The specification is based on the same production function as that used in the development of the TFP growth indices. It is simply a rearrangement of the logarithmic neutral production function as:

$$LnTFP(T) = \ln Y(T) - \alpha \ln K(T) - (1-\alpha)\ln L(T) \tag{78}$$

where Y(T) is output, K(T) capital stock, and L(T) labour input. α is the capital share that is equal to the elasticity of output with respect to capital stock. Clearly the differentiation of equation (78) is exactly the growth accounting for TFP growth. Coe and Helpman (1995) suggest investigation of the elasticity of the level of TFP with respect to research and development, by two variables reflecting domestic and foreign R&D capital stocks:

$$LnTFP(T) = \alpha_0 + \alpha_f \ln K_f^{R\&D}(T) + \alpha_d \ln L_d^{R\&D}(T) \tag{79}$$

where $K_f^{R\&D}$ and $L_d^{R\&D}$ are respectively foreign and domestic R&D capital stocks.

An examination of cointegration due to the concern of the potential problems from non-stationary is also suggested (Coe and Helpman 1995). Kao Chiang and Chen (1999) recently suggest a cointegration analysis in terms of panel data analysis associated with Gauss, however this analysis is not generally available in most of the latest econometric packages, such as Limdep 8.0, Pcgive 10.0 and State 8.0v. They report a consistent cointegration relationship among variables for the 22 selected OECD countries that are studied by Coe and Helpman (1995).

Huffman and Evenson (1993, Ch.7) suggest a single equation regression as equation (79), to investigate a number of explanatory variables for the study of agricultural TFP in an economy. They describe this analysis as statistical productivity decomposition methods (Huffman and Evenson, 1992; 1993). Birkhaeuser, Evenson and Feder (1991) employ it to examine the economic impact of agricultural extension. Huffman and Evenson (1992) also use it to explore the contributions of public and private research to the US agricultural productivity. A number of variables such as stocks of public and private research, public investments in crop- and livestock-oriented extension, farmers' education, weather and regional variables are included. Thirtle (1999) conducts a similar study for sugar production in the Eastern counties of England. He examines the association of sugar productivity only with R&D and the weather, possibly due to data restrictions.

Alternatively, the first differentiation of equation (79) will remove the potential problem of non-stationary given that there are cointegration relationships (Coe and Helpman 1995).

$$d\left(Ln(TFP(T))\right) = \alpha_0 + \alpha_f d\left(\ln K_f^{R\&D}\right) + \alpha_d d\left(\ln L_d^{R\&D}\right) \qquad (80)$$

equation (80) specifies the relationship between the TFP growth and the growth of R&D capital stocks. Coefficients α_d and α_f reflect respectively the elasticities of TFP with respect to domestic and foreign R&D capital stocks. Meanwhile, equation (80) also captures the recent theoretical development of growth accounting by Barro (1999) and Barro and Sala-i-Martin (2003). In addition, one could include more variables such as capital stock growth and human capital, if data were available.

For a majority of empirical studies, accounting for TFP growth is highly restricted by data availability, though a number of theories have been well developed. As a result, conventional growth accounting is still commonly used to provide first hand data on TFP, although there are serious concerns about the failure to address quality differences in inputs (Christensen, Cummings and Jorgensen 1980; 1981; Young 1995; Hsieh 1999; 2002; Barro 1999; Easterly and Levine 2001; Jorgenson and Yip 2001; and Barro and Sala-i-Martin 2003). Meanwhile, empirical regressions on TFP have less strong theoretical underpinnings than those on GDP, and are also more restricted by data availability. There are relatively rich empirical works on the USA (Jorgenson and Griliches 1967; Jorgenson, Gollop and Fraumeni 1987; Huffman and Evenson 1992; 1993). By contrast the studies on other economies, in particular for cross-country analysis, face rather more data restrictions.

2.3. Theoretical developments of neoclassical growth models

2.3.1. The Solow model

Solow (1956) assumes two factor inputs, capital and labour, in an economy associated with a Cobb-Douglas production function. The savings rate, labour growth, and technological progress are assumed to be determined exogenously and remain constant over time. There is perfect competition and constant returns to scale, and hence each factor is able to receive its marginal product. Technology is augmented with labour. Following Mankiw, Romer, and Weil (1992), the total output of such an economy at time t is determined by

$$Y(t) = (A(t)L(t))^{1-\alpha} K(t)^{\alpha} \qquad 0 < \alpha < 1 \qquad (81)$$

Y(t) is output, A(t) the level of the technological index, L(t) labour stock, and K(t) capital stock. Equation (81) can be rewritten in terms of per effective labour unit.

$$y(t) = k(t)^{\alpha} \qquad 0 < \alpha < 1 \qquad (82)$$

where y(t) = Y(t)/(A(t)L(t)) is defined as output per effective labour input and k(t)=K(t)/(A(t)L(t)) as capital stock per unit of effective labour. Labour and the level of technological index grow exogenously at speeds n and g respectively:

$$L(t) = L(0)e^{nt} \tag{83}$$

$$A(t) = A(0)e^{gt} \tag{84}$$

Thus the quantities of effective labour, A(t)L(t), grows at speed n + g:

$$A(t)L(t) = A(0)L(0)e^{(n+g)t} \tag{85}$$

It is worth noting that equations (83), (84) and (85) are approximations of the factor stock growths, whose accuracy depends on the absolute magnitudes of nt, gt, and (n+g)t. The advantage of this approximation is the mathematical convenience of the exponential function.

Suppose that a constant proportion of output, s, is saved and fully invested, then the capital stock per effective labour is determined by:

$$\dot{k}(t) = sy(t) - (n + g + \delta)k(t) \tag{86}$$

where δ is the depreciation rate of capital stock. Substituting equation (82) into equation (86) leads explicitly to the Solow convergence equation:

$$\dot{k}(t) = sk(t)^{\alpha} - (n + g + \delta)k(t) \tag{87}$$

Equation (87) implies that capital stock per effective labour k(t) converges to a steady-state k*, identified by $\dot{k}^* = sk^{*\alpha} - (n + g + \delta)k^* = 0$, and hence:

$$k^* = \left(\frac{s}{n + g + \delta}\right)^{\frac{1}{1-\alpha}} \tag{88}$$

Clearly, capital stock per effective labour around the steady state is determined by saving and population growth, provided that the depreciation rate and technological progress are identical across countries.

Substituting the steady-state k* into the initial production function (81) and taking natural logarithms, the steady-state output per capita is determined by:

$$\ln(\frac{Y(t)}{L(t)}) = LnA(0) + gt + \frac{\alpha}{1-\alpha}\ln s - \frac{\alpha}{1-\alpha}\ln(n+g+\delta) \qquad (89)$$

Mankiw, Romer, and Weil (1992) argue that A(0) could reflect both technology and other elements such as resource endowments, climate, or institutions, that might be not homogenous across countries. Therefore A(0) should pick up the difference of country-specification by country-specific shock, ε, and hence:

$$A(0) = c + \varepsilon \qquad (90)$$

where c is a constant term. Substituting this into equation (89) results in the following specification:

$$\ln(\frac{Y(t)}{L(t)}) = c + \frac{\alpha}{1-\alpha}\ln s - \frac{\alpha}{1-\alpha}\ln(n+g+\delta) + \varepsilon \qquad (91)$$

where the constant term c contains gt in equation (89).

The above specification provides an empirical framework for a test of the Solow model around steady states (Mankiw, Romer and Weil 1992; Islam 1995; Caselli, Esquivel and Lefort 1996; and Temple 1998). It is frequently abbreviated as the MRW model in literature. Clearly, country-specific shock ε is assumed to be independent of the explanatory variables, s and n, which legitimates the Ordinary Least Squares (OLS) estimation (Islam 1995).

Mankiw, Romer, and Weil (1992) further argue "In other words, the Solow model predicts convergence only after controlling for the determinants of steady state, a phenomenon that might be called 'conditional convergence'". In the neighbourhood of the steady state, in which y* is given by equation (91), the convergence speed is determined by:

$$\frac{d\ln y(t)}{dt} = \lambda(\ln y^* - \ln y(t)) \qquad (92)$$

where λ is the speed of convergence, i.e. growth slows down as the steady state is approached (Barro and Sala-i-Martin 2003: p56). λ is explicitly given by:

$$\lambda = -\frac{\partial(\frac{d(\ln y)}{dt})}{\partial(\ln y)} = -\frac{\partial(\dot{y}/y)}{\partial(\ln y)} \qquad (93)$$

Barro and Sala-i-Martin (2003: pp56-57) show that the convergence speed of capital stock equals that of output, given the production function equation (81). This can be seen from the following two equations, derived from (82):

$$\ln y = \alpha \ln k \qquad (94)$$

$$\frac{\dot{y}}{y} = \alpha(\frac{\dot{k}}{k}) \qquad (95)$$

Clearly from equations (93), (94), and (95), we get:

$$\lambda = -\frac{d(\dot{y}/y)}{d(\ln y)} = -\frac{d(\dot{k}/k)}{d(\ln k)} \qquad (96)$$

To obtain λ explicitly, we have to rearrange the capital stock equation (87) as:

$$\frac{\dot{k}(t)}{k(t)} = sk(t)^{\alpha-1} - (n+g+\delta) = s \cdot e^{-(1-\alpha)\ln k(t)} - (n+g+\delta) \qquad (97)$$

From the partial derivative of equation (97) with respect to ln*k(t)*, we can get:

$$\lambda = (1-\alpha) \cdot s \cdot k(t)^{-(1-\alpha)} \qquad (98)$$

Equation (98) shows that the convergence speed, λ, declines monotonically as the capital stock increases. As the capital stock reaches its steady-state level, at which equation (97) is set to be null, i.e. $sk(t)^{\alpha-1} = (n+g+\delta)$, the speed of convergence decreases to its minimum given by:

$$\lambda^* = (1-\alpha) \cdot (n+g+\delta) \qquad (99)$$

Equation (99) provides a formula to calculate the convergence speed of an economy around its steady state (Mankiw, Romer, and Weil 1992; Barro and Sala-i-Martin 1995; 2003). Having calibrated with USA data, Mankiw (1995) produced a convergence speed of 4%, while Barro and Sala-i-Martin (1995; 2003) suggested a USA convergence speed of 5%.

We can return to equation (92) because it suggests a possible model to explore the convergence speed where data are available. Rearranging it, we have:

$$\ln y(t) = (1 - e^{-\lambda t})\ln y^* + e^{-\lambda t}\ln y(0) \tag{100}$$

where y(0) is output per effective labour at the initial stage of each period being studied. Subtracting ln*y(0)* from both sides, we get:

$$\ln y(t) - \ln y(0) = (1 - e^{-\lambda t})\ln y^* - (1 - e^{-\lambda t})\ln y(0) \tag{101}$$

Replacing y* by equation (91), finally we have:

$$\begin{aligned} \ln y(t) - \ln y(0) &= c + (1 - e^{-\lambda t})\frac{\alpha}{1-\alpha}\ln s \\ &- (1 - e^{-\lambda t})\frac{\alpha}{1-\alpha}\ln(n + g + \delta) - (1 - e^{-\lambda t})\ln y(0) + \varepsilon \end{aligned} \tag{102}$$

Islam (1995) rewrites the above MRW specification within the standard notation of the panel data specification:

$$y_{it} = \gamma y_{i,t-1} + \sum_{j=1}^{2}\beta_j x_{it}^j + \eta_t + \mu_i + v_{it} \tag{103}$$

As can be seen, all the parameters in equation (102) can be calculated by the estimated coefficients of the above model. Islam (1995) presents them explicitly:

$$y_{it} = \ln y(t) \tag{104}$$

$$y_{i,t-1} = \ln y(0) \tag{105}$$

$$\gamma = e^{-\lambda t} \tag{106}$$

$$\beta_1 = -\beta_2 = (1 - e^{-\lambda t})\frac{\alpha}{1-\alpha} \tag{107}$$

$$x_{it}^1 = \ln s \tag{108}$$

$$x_{it}^2 = \ln(n+g+\delta) \tag{109}$$

$$\mu_t = (1-e^{-\lambda t})\ln A(0) \tag{110}$$

$$\eta_t = gt \tag{111}$$

The MRW model suggests that the growth of output is determined jointly by the determinants of the steady state and initial level of output. It is widely used to test the Solow model(Mankiw, Romer and Weil 1992; Islam 1995; Caselli, Esquivel and Lefort 1996; and Temple 1998). However it is highly structured and hence excludes many other factors that could substantially influence output growth.

2.3.2. The MRW model with human capital

Mankiw, Romer, and Weil (1992) argue that human capital can potentially change the course of economic growth. Ignoring human capital can empirically bias the analysis of cross-country growth regressions. To incorporate human capital into the Solow model, they redefine the production function as:

$$Y(t) = (A(t)L(t))^{1-\alpha-\beta} K(t)^{\alpha} H(t)^{\beta} \qquad 0<\alpha+\beta<1,\ 0<\alpha\ ,\ 0<\beta \tag{112}$$

H(t) is the stock of human capital. All capitals are assumed to exhibit decreasing returns and share the same depreciation rate, though constant returns to scale is maintained. Let s_k and s_h be respectively the investment rates of physical and human capital. All saving is used to invest in either physical or human capital. The evolution of the two capital stocks are governed respectively by:

$$\dot{k}(t) = s_k y(t) - (n+g+\delta)k(t) \tag{113}$$

$$\dot{h}(t) = s_h y(t) - (n+g+\delta)h(t) \tag{114}$$

As k(t) = K(t)/(A(t)L(t)) is capital stock per effective labour, h(t) = H(t)/(A(t)L(t)) is human capital stock per effective labour. The steady states of physical and human capital can hence be determined as:

$$k^* = \left(\frac{s_k^{1-\beta} s_h^{\beta}}{n+g+\delta}\right)^{\frac{1}{1-\alpha-\beta}} \tag{115}$$

$$h^* = \left(\frac{s_k^{\alpha} s_h^{1-\alpha}}{n+g+\delta}\right)^{\frac{1}{1-\alpha-\beta}} \tag{116}$$

Substituting (115) and (116) into the production function equation (112), and then taking logarithms results in per capita output at the steady state:

$$\begin{aligned}\ln\left(\frac{Y(t)}{L(t)}\right) &= LnA(0) + gt + \frac{\alpha}{1-\alpha-\beta}\ln s_k + \frac{\beta}{1-\alpha-\beta}\ln s_h \\ &- \frac{\alpha+\beta}{1-\alpha-\beta}\ln(n+g+\delta)\end{aligned} \tag{117}$$

Alternatively, equation (117) can be rewritten by replacing s_h with h* from equation (116):

$$\begin{aligned}\ln\left(\frac{Y(t)}{L(t)}\right) &= LnA(0) + gt + \frac{\alpha}{1-\alpha}\ln s_k + \frac{\beta}{1-\alpha}\ln h^* \\ &- \frac{\alpha+\beta}{1-\alpha-\beta}\ln(n+g+\delta)\end{aligned} \tag{118}$$

In the neighbourhood of the steady state, y* is identified by equation (118), and the convergence speed is determined by equation (92), being reproduced below:

$$\frac{d\ln y(t)}{dt} = \lambda(\ln y^* - \ln y(t)) \tag{119}$$

In contrast to equations (99), Mankiw, Romer, and Weil (1992), and in particular, Barro and Sala-i-Martin (2003: 59-61) show that the convergence speed of the economy around its steady state is determined by:

$$\lambda^* = (1-\alpha-\beta)\cdot(n+g+\delta) \tag{120}$$

An empirical model specification, analogous to (102), is specified as:

$$
\begin{aligned}
&\ln y(t) - \ln y(0) = \\
&c + (1 - e^{-\lambda t})\frac{\alpha}{1-\alpha-\beta}\ln s_k + (1 - e^{-\lambda t})\frac{\beta}{1-\alpha-\beta}\ln s_h \\
&- (1 - e^{-\lambda t})\frac{\alpha+\beta}{1-\alpha-\beta}\ln(n+g+\delta) - (1 - e^{-\lambda t})\ln y(0) + \varepsilon
\end{aligned} \qquad (121)
$$

It is very clear that the MRW model is a theoretically determined approach, in which including human capital requires a more structural specification of the production function. McDonald and Roberts (2002) extend the MRW specification to include health capital. But Islam (1995) and Caselli, Esquivel, and Lefort (1996) find it very difficult to address empirically the significance of human capital using the MRW model, because its coefficients are reported to be negative and significant. Temple (1998) shows that estimated parameters of the MRW specifications are highly sensitive to measurement error. The model is very hard to extend further to encompass non-capital variables such as inflation, general government expenditure, trade, and institutional variables.

There are three additional drawbacks to the MRW specification. Firstly, the saving rate or its equivalent, the investment rate, is determined exogenously (Barro and Sala-i-Martin 2003: p83). Secondly, the estimates of the augmented Solow – MRW model are highly sensitive to measurement error (Temple 1998). Thirdly, the MRW model sketches the picture of economic growth around its steady state. Any significant departure from the steady state reduces the applicability of the MRW model, and hence increases the likelihood that its application will produce a distorted picture of growth.

2.3.3. Growth models with consumer optimisation

The Solow (1956) model can be further expanded to address an economy allowing consumers to maximize their utilities. Modelling consumer behaviour is a main component in the growth model of Ramsey (Ramsey 1928; Cass 1965; Koopmans 1965; Lucas 1988, Barro and Sala-i-Martin 1995; 2003). However, the developments of theory differ depending upon the specifications of the detailed utility and production functions. Lucas (1988) develops the Solow model to study the determinants of consumers' preference in a number of circumstances. Barro and Sala-i-Martin (1995), Durlauf and Quah (1999), and Barro and Sala-i-Martin (2003: p85-135) examined the convergence concept with consumer optimisation. This section sketches the key developments of the theory following Durlauf and Quah (1999) and Barro and Sala-i-Martin (2003).

2.3.3.1 Households and consumer optimisation

Households are assumed to be identical. Each consumer is a representative sharing the same preference parameters, the same wage rate, and the same endowments. Labour or population is assumed to grow exogenously at the rate of n and initial level of labour is normalised to unity:

$$L(t) = e^{nt} \tag{122}$$

c(t)=C(t)/L(t)) is consumption per capita. Preferences are governed by the utility function:

$$\int_0^\infty \frac{c(t)^{1-\theta} - 1}{1-\theta} e^{(n-\rho)t} dt \tag{123}$$

where the discount rate ρ and the inter-temporal elasticity of substitution θ^{-1} are both positive. θ is also known as the coefficient of relative risk aversion. Households face a budget constraint, which is determined by assets per capita, k, consumption per capita, c, the interest rate, r, the wage rate, w, and the growth rate of population, n.

$$\dot{k}(t) = w + (r - n)k(t) - c(t) \tag{124}$$

This optimisation problem can be resolved by maximizing the current-value Hamiltonian function defined as:

$$H(k, c, \varphi, t) = e^{(n-\rho)t} \frac{c(t)^{1-\theta}}{1-\theta} + \varphi[w + (r - n)k(t) - c(t)] \tag{125}$$

where variable φ, the Langrage multiplier, is the current value shadow price of income. The first order conditions for the maximisation of utility are:

$$\frac{\partial H}{\partial c} = c^{-\theta} e^{(n-\rho)t} - \varphi = 0 \tag{126}$$

$$\frac{\partial H}{\partial k} = -\dot{\varphi} = (r - n)\varphi \tag{127}$$

Differentiating equation (126) with respect to time and then replacing both $\dot{\varphi}$ and φ in equation (127), we have:

$$\frac{\dot{c}}{c} = \frac{r - \rho}{\theta} \tag{128}$$

This equation demonstrates the relationship between r, ρ, and θ. Provided that the risk aversion attitude - the coefficient, θ, is given, r and ρ determine the styles of households' consumption (Barro and Sala-i-Martin, 2003: p91). However Lucas (1988) shows that θ and ρ are jointly determined and hence cannot be separately identified along a smooth consumption path.

2.3.3.2 Firms and profit maximisation

Firms are assumed to be identical. They adopt a Cobb-Douglas production function, paying wages and rents to labour and capital inputs respectively.

$$Y(t) = (A(t)L(t))^{1-\alpha} K(t)^{\alpha} \qquad 0 < \alpha < 1 \tag{129}$$

where the level of technology grows at a constant rate x, and hence A(t) = e^{xt} , and initial A(0) is normalised to unity. This production function can be rewritten in per effective capita terms as:

$$\hat{y}(t) = \hat{k}(t)^{\alpha} \tag{130}$$

where $\hat{y}(t) = Y(t)/(e^{xt}L(t))$, $\hat{k}(t) = K(t)/(e^{xt}L(t))$, and $\hat{L}(t) = e^{xt}L(t)$. The Inada conditions are applied, i.e. $\partial\hat{y}/\partial\hat{k} \to \infty$ as $\hat{k} \to 0$ and $\partial\hat{y}/\partial\hat{k} \to 0$ as $\hat{k} \to \infty$. The representative firms aim at maximising their profit, which is given by:

$$\pi = \hat{L} \cdot [\hat{k}(t)^{\alpha} - (r+\delta) \cdot \hat{k}(t) - w \cdot e^{-xt}] \tag{131}$$

Under the perfect market condition, profits are zero, and we have:

$$r + \delta = \alpha \cdot \hat{k}(t)^{\alpha-1} \tag{132}$$

$$w = (1-\alpha) \cdot e^{xt} \cdot \hat{k}(t)^{\alpha} \tag{133}$$

2.3.3.3 Market equilibrium

The interaction between firms and households, under the perfect market condition, eventually reaches equilibrium. Substituting r and w from equations (132) and (133) into the households' budget constraint, equation (124), we get:

$$\dot{\hat{k}}(t) = \hat{k}(t)^{\alpha} - (x+n+\delta)\hat{k}(t) - \hat{c}(t) \tag{134}$$

where $\hat{k}(t) = e^{-xt}k(t)$, and $\hat{c}(t) = C/(e^{xt}L(t)) = c \cdot e^{-xt}$. This equation is the resources constraint for the whole economy. It determines the key evolution of $\hat{k}(t)$, and hence $\hat{y}(t)$.

The consumption, $\hat{c}(t)$, evolves according to households' optimisation which is governed by equation (128). Substituting equation (132) into (128), we can get:

$$\frac{\dot{\hat{c}}(t)}{\hat{c}(t)} = \frac{\dot{c}}{c} - x = \frac{1}{\theta} \cdot (\alpha \cdot \hat{k}(t)^{\alpha-1} - \delta - \rho - \theta \cdot x) \qquad (135)$$

This equation, associated with equation (134), forms an economic system, which, together with the initial condition of capital stock and the transversality condition, determines the evolutions of the consumption and capital accumulation. For the further discussion about the transversality condition see Barro and Sala-i-Martin (2003: pp 91-94).

2.3.3.4 Evolution of output and capital stock

To see the roles of equations (134) and (135) in governing the time paths of output and capital accumulation, we rewrite them in logarithmic terms:

$$\begin{aligned} \frac{d \ln \hat{k}(t)}{dt} &= \frac{\dot{\hat{k}}(t)}{\hat{k}(t)} = \hat{k}(t)^{\alpha-1} - (x+n+\delta) - \hat{c}(t)/\hat{k}(t) \\ &= e^{-(1-\alpha)\cdot \ln \hat{k}(t)} - e^{\ln(\hat{c}(t)/\hat{k}(t))} - (x+n+\delta) \end{aligned} \qquad (136)$$

$$\begin{aligned} \frac{d \ln \hat{c}(t)}{dt} &= \frac{\dot{\hat{c}}(t)}{\hat{c}(t)} = \frac{1}{\theta}[\alpha \cdot \hat{k}(t)^{\alpha-1} - (\rho + x \cdot \theta + \delta)] \\ &= \frac{1}{\theta}[\alpha \cdot e^{-(1-\alpha)\cdot \ln \hat{k}(t)} - (\rho + x \cdot \theta + \delta)] \end{aligned} \qquad (137)$$

In the steady state, equations (136) and (137) are both set to equal zero. The optimal $\hat{k}*$, and $\hat{c}(t)*$ can be found from two equations below:

$$e^{-(1-\alpha)\cdot\ln \hat{k}(t)} - e^{\ln(\hat{c}(t)/\hat{k}(t))} = (x+n+\delta) \tag{138}$$

$$\frac{1}{\theta}[\alpha \cdot e^{-(1-\alpha)\cdot\ln \hat{k}(t)} = (\rho + x\cdot\theta+\delta)] \tag{139}$$

Taking a first-order Taylor expansion of the system determined by equations (136) and (137) at the steady-state governed by equations (138) and (139), we have:

$$\begin{pmatrix} \frac{d\ln\hat{k}(t)}{dt} \\ \frac{d\ln\hat{c}(t)}{dt} \end{pmatrix} = \begin{pmatrix} \zeta & x+n+\delta-\frac{\rho+x\cdot\theta+\delta}{\alpha} \\ -(1-\alpha)\frac{\rho+x\cdot\theta+\delta}{\theta} & 0 \end{pmatrix} \cdot \begin{pmatrix} \ln(\frac{\hat{k}}{\hat{k}^*}) \\ \ln(\frac{\hat{c}}{\hat{c}^*}) \end{pmatrix} \tag{140}$$

where ζ = ρ – n – x (1-θ), and the determinant of the characteristic matrix is given by:

$$\det\begin{pmatrix} \frac{d\ln\hat{k}(t)}{dt} \\ \frac{d\ln\hat{c}(t)}{dt} \end{pmatrix} = (1-\alpha)[x+n+\delta-\frac{\rho+x\cdot\theta+\delta}{\alpha}]\frac{\rho+x\cdot\theta+\delta}{\theta} \tag{141}$$

The transversality condition implies (ρ + x·θ – n – x) > 0, and $0<\alpha<1$, which leads to a positive determinant of the characteristic matrix, denoted by equation (141). This implies the two eigenvalues associated with opposite signs, which further implies the saddle-path of stability of the consumption and capital accumulation per effective labour. The convergence speed, λ, around the steady state is the negative eigenvalue, which can be found by using the condition below:

$$\det\begin{pmatrix} \zeta-(-\lambda) & x+n+\delta-\dfrac{\rho+x\cdot\theta+\delta}{\alpha} \\ -(1-\alpha)\dfrac{\rho+x\cdot\theta+\delta}{\theta} & -(-\lambda) \end{pmatrix}=0 \qquad (142)$$

This can be rearranged in a quadratic equation in λ:

$$\lambda^2+\zeta\cdot\lambda+(1-\alpha)[x+n+\delta-\frac{\rho+x\cdot\theta+\delta}{\alpha}]\frac{\rho+x\cdot\theta+\delta}{\theta}=0 \qquad (143)$$

It has two solutions, in which the convergence speed around the steady state is given by:

$$2\lambda=-\zeta+\{\zeta^2+4(1-\alpha)[x+n+\delta-\frac{\rho+x\cdot\theta+\delta}{\alpha}]\frac{\rho+x\cdot\theta+\delta}{\theta}\}^{1/2} \qquad (144)$$

Barro and Sala-i-Martin (2003: p. 112) demonstrate that with a constant saving rate, the convergence coefficient, λ, can be simplified as:

$$\lambda^*=(1-\alpha)\cdot(n+g+\delta) \qquad (145)$$

The time paths for $\hat{k}(t)$, and $\hat{y}(t)$ are governed respectively by:

$$\ln\hat{k}(t)=(1-e^{-\lambda t})\ln\hat{k}^*+e^{-\lambda t}\ln\hat{k}(0) \qquad (146)$$

$$\ln\hat{y}(t)=(1-e^{-\lambda t})\ln\hat{y}^*+e^{-\lambda t}\ln\hat{y}(0) \qquad (147)$$

The above two equations take the same form as equation (100).

Clearly, the growth model with consumers' optimisation imposes much more theoretical structure. In practice, it is difficult to specify an econometric model that strictly follows the theory. Including human capital becomes much more complicated (Lucas 1988; Durlauf and Quah 1999). Therefore Barro and Sala-i-Martin (1991; 1992; 1995; 2003) suggest a general empirical specification to capture the key theoretical idea of economic convergence.

2.3.4. Empirical studies

There is a large literature of empirical studies on neoclassical growth theories. Except for those interested in the steady-state convergence coefficient that can be calibrated with the information from a particular economy, such as the USA (Mankiw, 1995; Barro and Sala-i-Martin, 1995, 2003), a majority of the studies employ statistical regressions to explore the possible determinants of economic growth. The intentions are to capture the convergence concept, together with the determinants of the steady state, such as human capital, the investment ratio, the inflation rate, and international trade (Barro and Sala-i-Martin 1991, 1992, Barro and Lee 1994, Caselli, Esquivel, and Lefort 1996, Barro 1997, and Barro and Sala-i-Martin 2003). Among those studies, Islam (1995), and in particular Caselli, Esquivel, and Lefort (1996) suggest abandoning the structural specification of the MRW specification because of the unexpected significantly negative coefficients on human capital.

2.3.4.1 Calibration of the convergence coefficient

The calibrations of the convergence coefficient depend on the deduced equations (99), (120) and (144). These exercises are primarily conducted with USA data. For convenience, we duplicate equations (99) and (120) below:

$$\lambda^{*} = (1-\alpha)\cdot(n+g+\delta) \tag{148}$$

$$\lambda^{*} = (1-\alpha-\beta)\cdot(n+g+\delta) \tag{149}$$

Barro and Sala-i-Martin (1995, 2003) assume that x = 0.02, n = 0.01, δ = 0.05, and α = 0.33 for the American economy. Using equation (148), they deduce a convergence coefficient of 5.6, which literally suggests that the USA needs to take 12.5 years to get to its steady state. By contrast, Mankiw (1995) employs equation

(149), and produces a convergence coefficient of 4.0, in which human capital is addressed.

Given the general economic and technical leadership of the USA, it is reasonable to hypothesize that follower countries could potentially achieve higher convergence speeds. A number of catch-up mechanisms that can increase convergence include imitation, diffusion, spill-over, learning by doing, and exporting students to study in leader economies. However insofar as the USA has a more efficient market system than other countries, it will be better able to capitalise on any given technical advance, and that in itself would widen the productivity gap that other countries might hope to close.

2.3.4.2 Empirical evidence based on the MRW model

Mankiw, Romer and Weil (1992) demonstrate that an augmented Solow model, with human capital, provides a good explanation of the cross-country data. However, this view is challenged by three further studies in which more appealing statistical methods are employed (Islam 1995, Caselli, Esquivel, and Lefort 1996, and Temple 1998). All those studies follow the MRW specifications (equations (102) and (121)), which are rewritten as:

$$\begin{aligned}&\ln y(t) - \ln y(t-\tau) = \\ &c + (1-e^{-\lambda\tau})\frac{\alpha}{1-\alpha-\beta}\ln s_k + (1-e^{-\lambda\tau})\frac{\beta}{1-\alpha-\beta}\ln s_h \\ &-(1-e^{-\lambda\tau})\frac{\alpha+\beta}{1-\alpha-\beta}\ln(n+g+\delta) - (1-e^{-\lambda\tau})\ln y(t-\tau) + \varepsilon\end{aligned} \qquad (150)$$

where the convergence coefficient around its steady state, in which human capital included, is given by:

$$\lambda^* = (1-\alpha-\beta)\cdot(n+g+\delta) \qquad (151)$$

Table 2.2 summarises some results from several relevant empirical studies. As in Mankiw, Romer and Weil (1992), human capital, approximated by the average percentage of the working-age population in secondary school, is positively and significantly associated with the GDP growth rate[1]. Therefore, the elasticity of output with respect to human capital is positive. This result is consistent across unrestricted and restricted regressions.

However, Islam (1995) reports a significantly negative β coefficient with a more statistically preferable fixed panel data method, after criticising the weakness of the single cross-section regression conducted by Mankiw, Romer and Weil (1992), This "anomalous" result persists regardless of the choice of the sample. Unfortunately, Islam (1995) does not provide a convincing explanation of the results, given that the MRW model is generally accepted.

By contrast, Caselli, Esquivel, and Lefort (1996) substantially alter the view on the MRW model. After critically reviewing the literature, they use a dynamic panel data method with generalised method of moments to redo the work of Mankiw, Romer and Weil (1992). As can be seen, they also found a significantly negative β coefficient, the same puzzle uncovered by Islam (1995). Caselli, Esquivel, and Lefort (1996) argue that the assumptions of the conventional Solow model are inconsistent with the evidence, and that the augmented Solow model is not supported by the empirical tests. As a result, they suggest abandoning the MRW framework as an econometric specification, and hence seek alternatives.

Some later studies also fail to report consistent, positive and significant coefficients on human capital. Temple (1998) finds that the coefficients on school

[1] The variable is created, using data on the fraction of the eligible population (aged 12 to 17) enrolled in secondary school, from the UNESCO yearbook, multiplied by the fraction of the working-age population that is of school age (aged 15 to 19)

are sensitive to measurement error and not always positive. McDonald and Roberts (2002) report insignificant positive coefficients on education, but these are sensitive to the inclusion of life expectancy. McDonald and Roberts (2005) produce a negative coefficient on the education variable, though it is insignificant.

TABLE 2.2

TESTS FOR THE AUGMENTED SOLOW MODEL AND CONDITIONAL CONVERGENCE

Studies	MRW	ISLAM	CEL(1)	CEL(2)
Ln GDP(t-τ)	-0.289 (0.062)	N/A	N/A	N/A
Ln (investment ratio)	0.524 (0.087)	N/A	N/A	N/A
Ln (n+g+δ)	-0.505 (0.288)	N/A	N/A	N/A
Ln(school)	0.233 (0.060)	N/A	N/A	N/A
Unrestricted λ	0.0137 (0.0019)	N/A	0.0106 (0.0028)	0.0790 (0.0184)
Ln(school)−Ln(n+g+δ)	0.238 (0.060)	-0.0712 (0.0323)	N/A	N/A
Restricted λ	0.0142 (0.0019)	0.0375 (0.0093)	0.0107 (0.0027)	0.0679 (0.0206)
Implied α	0.48 (0.07)	0.52 (0.06)	0.50 (0.08)	0.49 (0.11)
Implied β	0.23 (0.05)	-0.20 (0.11)	0.18 (0.05)	-0.26 (0.12)
Countries	98	79	97	97
Observations	98	345	479	377
Method of estimation	OLS	LSDV	OLS	GMM

Columns MRW and ISLAM duplicate results reported, respectively, in Mankiw, Romer and Weil (1992, table 4 and 6) and in Islam (1995, table 5). The MRW results are estimated by a single cross-section Ordinary Least Squares (OLS) method, and the ISLAM ones by a fixed effect panel data method. Column CEL(1) and CEL(2) reproduce results from Caselli, Esquviel and Lefort (1996, table 3). They are estimated respectively by OLS and generalised method of moments.

Standard errors are in parentheses. GDP(t-τ) is GDP per working-age person in 1960. The investment and population growth rates are averages for the period 1960-1985. (g+δ) is assumed to be 0.05. SCHOOL is the average percentage of the working-age population in secondary school for the period 1960-1985.

Implied λ , α, and β are respectively calculated from estimated parameters, in which the coefficient on Ln GDP(t-τ) is – $[1\text{-exp}^{-\lambda\tau}]$; the coefficient on ln(school)-ln(n+g+δ) is $\beta[1-e^{-\lambda\tau}]/(1-\alpha-\beta)$; and the coefficient on ln(investment ratio)-ln(n+g+δ) is $\alpha[1-e^{-\lambda\tau}]/(1-\alpha-\beta)$.

In addition, table 2.2 shows that panel data methods produce a higher convergence coefficient than conventional cross-section regression with ordinary least squares. Mankiw, Romer and Weil (1992) report a slow convergence coefficient of around 2%. By contrast, Islam (1995) produces a higher convergence coefficient at 3.75% for the whole sample, and much higher at 9.13% for the OECD group. Similarly Caselli, Esquivel, and Lefort (1996) generate a high convergence coefficient at 6.79% using a dynamic panel data method. Temple (1998) finds that the convergence rates are sensitive to measurement error. high convergence coefficients are also reported by McDonald and Roberts (2002; 2005). The results suggest that most economies are closer to their steady states than earlier results suggested (Mankiw 1995; Caselli, Esquivel, and Lefort 1996).

2.3.4.3 Empirical convergence studies associated with general specifications

The large empirical expansion of the convergence studies mainly stem from flexible general specifications (Barro 1991; Barro and Sala-i-Martin 1991; 1992; Barro and Lee 1994; Barro and Sala-i-Martin 1995; Caselli, Esquivel, and Lefort 1996; Barro 1997; and Barro and Sala-i-Martin 2003). The general specifications can capture the core concepts of the convergence and other features in neoclassical growth theories.

(1) Diminishing returns to capital is a key assumption for neoclassical theories. Barro and Sala-i-Martin (1995, 2003) show that, under certain conditions, the determinants of the convergence of per effective output are equivalent to that of per effective capital stock around steady state.

(2) The convergence property is conditional in the sense that the steady-state values of capital stock and output are determined by a number of variables. In theory, the steady state is determined by the saving rate, population growth, technological progress, and the factor elasticity of the production function (Mankiw, Romer and Weil 1992; Barro and Sala-i-Martin 1995; 2003).

(3) The convergence coefficient is positively associated with the distance between the present and the steady state output values of an economy. Hence its convergence speed is expected to be faster the further it is from its steady state (Barro and Sala-i-Martin 1991, 1992, 1995, 2003).

The general specification is flexible enough to allow more explanatory variables. The MRW specification is a specific case of the general specification. Caselli, Esquivel, and Lefort (1996), Barro (1997) and Barro and Sala-i-Martin (2003) suggest that the economy's steady state could be determined by a number of choices and environmental variables, which are selected empirically depending on the research objective and data availability. This implies we would be too cautious to restrict our empirical analysis to the limited range of variables suggested by the contested MRW model (Caselli, Esquivel, and Lefort 1996).

Table 2.3 represents the results of some empirical studies for general cross-country regressions. As can be seen, the coefficients of some explanatory variables are very robust while others are sensitive to the specifications and statistical methods. Most of those differences possibly result from panel data regression, in particular when panel data regression is estimated by the generalised method of moments. The selected results are taken from Barro and Lee (1994), Caselli, Esquivel, and Lefort (1996), Barro (1997), and Barro and Sala-i-Martin (2003).

TABLE 2.3

SELECTED STUDIES OF CROSS-COUNTRY GROWTH REGRESSIONS

Variable	Barro-Lee	Barro	Barro-Sala-i-Martin	CEL(1)	CEL(2)	CEL(3)
Ln GDP(t-τ)	-0.0255 (0.0035)	-0.0254 (0.0031)	-0.0248 (0.0029)	-0.0770 (0.009)	-0.0652 (0.008)	-0.0792 (0.006)
Male education	0.0138 (0.0042)	0.0118 (0.0025)	0.0036 (0.0016)	-0.0399 (0.0080)	-0.0262 (0.0081)	-0.0181 (0.0065)
Male education*Ln[GDP(t-τ)]	N/A	-0.0062 (0.0017)	N/A	N/A	N/A	N/A
Female education	-0.0092 (0.0047)	N/A	N/A	0.0604 (0.0100)	0.0315 (0.0094)	0.0298 (0.0070)
Ln (life expectancy)	0.0801 (0.0139)	0.0423 (0.0137)	0.0423 (0.0137)	-0.00108 (0.03208)	N/A	N/A
Ln (total fertility rate)	N/A	-0.0161 (0.0053)	-0.0118 (0.0050)	N/A	N/A	N/A
Inflation rate	N/A	-0.043 (0.008)	-0.019 (0.010)	N/A	N/A	N/A
Investment ratio	0.077 (0.027)	N/A	0.083 (0.024)	0.126 (0.038)	0.0972 (0.038)	0.151 (0.028)
Government consumption ratio	-0.155 (0.034)	-0.136 (0.026)	-0.062 (0.023)	0.299 (0.045)	0.237 (0.049)	0.162 (0.050)
Terms of trade	N/A	0.137 (0.030)	0.130 (0.053)	N/A	N/A	0.0566 (0.0179)
Openness ratio	N/A	N/A	0.0054 (0.0048)	N/A	N/A	N/A
Democracy index	N/A	0.090 (0.027)	0.079 (0.028)	N/A	N/A	N/A
Democracy index squared	N/A	-0.088 (0.0247)	-0.074 (0.025)	N/A	N/A	N/A
Ln(1+Black Market Premium)	-0.0304 (0.0094)	N/A	N/A	-0.0364 (0.0045)	-0.0491 (0.0085)	-0.0318 (0.0075)
Revolution	-0.0178 (0.0089)	N/A	N/A	-0.0261 (0.0051)	N/A	N/A
Rule of Law	N/A	0.0293 (0.0054)	0.0185 (0.0059)	N/A	N/A	N/A
Assassination	N/A	N/A	N/A	N/A	-0.0789 (0.0044)	-0.0811 (0.0040)
Implied λ	0.0294 (0.0040)	N/A	N/A	0.0972 (0.0140)	0.0789 (0.0125)	0.101 (0.010)
Countries	85	87	86	91	93	90
Observations	180	251	241	316	319	302
Method of estimation	3SLS	3SLS	3SLS	GMM	GMM	GMM

Columns Barro-Lee, Barro, and Barro-Sala-i-Martin reproduce results reported, respectively, from Barro and Lee (1994, table 5), Barro (1997, table 1.1) and Barro and Sala-i-Martin (2003, table 12.3). They are estimated by Three Stage Least Squares (3SLS). Column CEL(1), CEL(2) and CEL(3) reproduce results from Caselli, Esquviel and Lefort (1996, table 4). They are in the dynamic panel data specifications estimated by generalised method of moments. Except for the recent study by Barro and Sala-i-Martin (2003) who employ ten years' average data, all other studies use five-year period data.

Standard errors are in parentheses. Y(t-τ) is GDP per capita of the first year for the period t-τ to t. Implied λ is calculated from estimated coefficient on lnGDP(t-τ), which is $-(1-e^{-\lambda\tau})$

The typical econometric model associated, with panel data specification, is specified as:

$$\ln y_i(t) - \ln y_i(t-\tau) = \beta \ln y_i(t-\tau) + \phi X_i(t-\tau,t) + \eta_i + \xi_t + \varepsilon_{i,t} \qquad (152)$$

where $y_i(t)$ is per capita GDP in country i for period t, $X_i(t)$ is a row vector of determinants of economic growth. η_i is a country specified effect, ξ_t is a period specified constant term, and $\varepsilon_{i,t}$ is an error term.

The standard explanation of equation (152) depends on the coefficient β and coefficient vector Φ. A significant negative coefficient, β, is interpreted as growth convergence to its steady state with a speed approximately $-\beta$. Other explanatory variables, $X_i(t)$, and the country effect, η_i, determine the long run or steady state value of the economy. The choice of $X_i(t)$ depends on the focus of the particular neoclassical growth model as well as data availability. It is not difficult to see that the MRW model is a particular specification of equation (152) with limited variables. Equation (152) can be rearranged as:

$$\ln y_i(t) = (1+\beta) \ln y_i(t-\tau) + \phi X_i(t-\tau,t) + \eta_i + \xi_t + \varepsilon_{i,t} \qquad (153)$$

Equation (153) is widely referred to as the dynamic panel data specification (Arellano and Bond 1991; Islam 1994; Caselli, Esquviel and Lefort 1996; and Baltagi 2005). Arellano and Bond (1991), Caselli, Esquviel and Lefort (1996) and Baltagi (2005) suggest that equation (153) can be estimated alternatively by GMM in which the possible endogeneity of country specified effects is resolved by the instruments created within the model. The first study to re-examine the convergence studies by GMM was probably by Caselli, Esquviel and Lefort (1996).

2.3.4.3.1 Initial level of GDP per capita

Table 2.3 shows significantly negative coefficients on the initial level of per capita GDP, *Ln*GDP(t-τ), for all specifications. It implies that conditional economic convergence can be consistently observed regardless of the specification and estimating methods. As can be seen, Barro and Lee (1994), Barro (1997) and Barro and Sala-i-Martin (2003) report low annual convergence coefficients of around 2.5 percent. These are close to the results reported by Mankiw, Romer and Weil (1992). The implication is a slow convergence process, i.e. an economy takes several decades to converge to its own steady state.

In contrast, Caselli, Esquviel and Lefort (1996) produce a higher convergence speed of around ten per cent. This implies that an economy might take relatively short period to reach its steady state. They conclude that most economies are probably relatively close to their steady states. These results are backed by the results reported by Islam (1995) who uses a fixed panel data approach based on the MRW model. McDonald and Roberts (2002; 2005) also provide supportive evidence. It seems that panel data methods generally produce higher convergence speeds than the conventional consensus.

2.3.4.3.2 Human capital

There is no obvious variable to perfectly reflect human capital (Markiv, Romer, and Weil, 1992). Human capital can be approximated by a group of variables. Education and health are commonly used. Barro (1991) suggests school enrolment rates to stand for the flow of investment in human capital. Mankiw, Romer and Weil (1992), Islam (1995), and Caselli, Esquviel and Lefort (1996) employ the average percentage of the working-age population in secondary school as a variable to reflect human capital. Barro (1997) suggests three variables to jointly represent the initial level of human capital. The average year of attainment for males aged twenty-five and over in secondary and higher schools at the start of each period is used to represent human capital indicated by schooling or education. The log of life expectancy at birth, at the start of each period, is used to indicate health status. And an interaction between the log of initial GDP per capita and the years of male secondary and higher schooling is also included to capture the education effect on convergence. Barro and Lee (1994), and Barro and Sala-i-Martin (1995; 2003) also include both male and female schooling in the analysis. McDonald and Roberts (2002) use life expectancy and infant mortality to proxy for health capital.

Unfortunately the empirical results are not always consistent with the theoretical expectation that human capital boosts the economy. It is undeniable that a number of empirical studies report significantly positive coefficients on human capital. Firstly, Barro and Lee (1994), and Barro and Sala-i-Martin (1995) report both significant and positive coefficients on male education but negative ones on female education. The negative coefficients on female education are probably explained by the argument that female education has a strong negative relation with the fertility rate, which are also included in the regression (Barro 1997: p21). Secondly, Barro (1997) finds the coefficient on primary schooling is insignificant and even negative. A possible explanation is that primary schooling is a prerequisite for further training rather than a direct cause of growth. Thirdly, Barro and Sala-i-Martin (1995), Barro (1997), and Barro and Sala-i-Martin (2003) report significantly positive coefficients on life expectancy, as expected. This seems to confirm health enhances economic growth. In addition, Barro (1997) reports a significant coefficient on the interaction between the log of initial GDP per capita and the years of male secondary and higher schooling. He argues that the result supports the theories that education has a positive effect on an economy's capacity to absorb technology. It seems that the results presented by Barro and Lee (1994), Barro and Sala-i-Martin (1995); Barro (1997) and Barro and Sala-i-Martin (2003) are relatively consistent with one another.

However, Caselli, Esquviel and Lefort (1996) produce almost the opposite results, estimated by a dynamic panel data method. As can be seen from table 2.3, columns CEL(1), CEL(2) and CEL(3) all report significantly negative coefficients on male education but a significantly positive one on female education. They argue that the female education variable captures both negative fertility effects and a positive human capital effect. As the former out-weights the latter, a positive coefficient is expected. However, it is difficult to interpret the negative coefficient on male education. Interestingly the negative coefficients on education variables seem to be consistent with the results from the MRW model reported by Islam (1995) and Caselli, Esquviel and Lefort (1996). McDonald and Roberts (2005) also report a negative coefficient on schooling, though it is insignificant. In addition, Caselli, Esquviel and Lefort (1996) report a negative and insignificant coefficient on life expectancy. By contrast, McDonald and Roberts (2002) produce a positive coefficient on life expectancy, except for OECD countries. However, inclusion of life expectancy switches the sign of the education variable from positive to negative.

2.3.4.3.3 Fertility rate

A growing population means that an increasing proportion of investment has to be allocated to new labour rather than to increase capital per capita (Barro 1997).

The growth of population is primarily driven by a higher fertility rate if the mortality rate remains constant. A high fertility rate also implies that more resources have to be channelled away to child bearing and rearing from the production sector. As a result, a higher fertility rate is expected to reduce growth capacity. This is consistently supported by a number of studies (Barro and Lee 1994; Barro and Sala-i-Martin 1995; Barro 1997; and Barro and Sala-i-Martin 2003).

However the fertility decision is likely to be determined endogenously. Schultz (1989), Behrman (1990), Barro and Lee (1994) suggest that the fertility rate is negatively associated with female education (Barro 1997: p24). Barro (1997) suggests using the lagged fertility rate as an instrument to reveal the growth impact of the fertility rate. For given values of other variables such as GDP and life expectancy, instrumental variables estimation is likely to demonstrate the real relationship between fertility and growth.

2.3.4.3.4 Investment Decision

The investment decision reflects consumers' preferences in a closed neoclassical growth model (Barro 1997). The ratio of investment to output is assumed to be equal to the exogenously determined savings rate. The increase of the savings rate is expected to raise the steady state output and hence to accelerate the growth rate. Delong and Summers (1991), Mankiw, Romer, and Weil (1992), Barro and Lee (1994), Barro and Sala-i-Martin (1995), Islam (1995), and Caselli, Esquviel and Lefort (1996) report significant positive associations between the investment ratio and growth.

There are concerns about the endogeneity of investment ratio (Blomstrom, Lipsey, and Zejan 1993; Barro 1997). For this reason, Barro (1997) excludes the investment ratio from the growth regression. Instead he suggests a regression of the investment ratio on a number of variables and finds that some growth enhancing variables also stimulate investment. Nevertheless in a later work Barro and Sala-i-Martin (2003) include the investment ratio in their regression. They employ lagged variables as instruments to deal with the problem of endogeneity. The results confirm the positive link from investment to growth.

2.3.4.3.5 Inflation

Low and stable inflation is one of the major targets for monetary policies, because inflation is generally believed to be costly (Briault 1995; Barro 1997 p. 89-90). Barro(1997) argues that both investors and consumers perform badly when inflation is high and uncertain, while Briault (1995) reviews the theoretical development about the costs of inflation. Barro and Sala-i-Martin (1995), Barro (1997), and Barro and Sala-i-Martin (2003) report significant negative associations between the inflation rate and growth.

Barro (1997) further examines the determinants of the inflation rate. Some variables significantly associated with GDP are also reported significant in his regression on the inflation rate. For instance, GDP and general government consumption are significantly and negatively related to the inflation rate. This suggests that the inflation rate is possibly determined endogenously in growth regression. Barro and Sala-i-Martin (2003) use ex-colony dummies as instruments for the former colonies of Britain, France, Portugal, Spain and others. These dummies explained a large part of inflation. Barro and Sala-i-Martin's results consistently support the negative relationship between inflation and growth

2.3.4.3.6 General Government Consumption

General government consumption reflects the size of government. Barro and Sala-i-Martin (1995) suggest an inverse U curve to demonstrate the relationship between government size and per capita growth. They argue that a positive relation might dominate when general government consumption is small, because the benefit from the provision of public goods outweighs the distortion cost of taxation. That relation could reverse when general government consumption is larger, and its cost exceeds the benefit.

However Atkinson (1996), reviewing the aggregate relationship between economic performance and the size of the welfare, concludes there is unlikely to be a straightforward relation between the two. And in fact in growth literature, while Barro and Lee (1994), Barro and Sala-i-Martin (1995), Barro (1997) and Barro and Sala-i-Martin (2003) report a negative association between growth and the general government consumption ratio, Caselli, Esquivel and Lefort (1996) report a positive linkage between the two variables.

2.3.4.3.7 International Trade

International trade is generally thought to be good for growth. The benefits can range from a possible expansion of aggregate demand, to cheaper imported goods and technological spillover. However, international trade implies more competition that might threaten less competitive industries, in particular for developing countries.

Barro (1997) suggests that the terms of trade have important influences on developing countries, many of which specialise in a few primary goods. The terms of trade are measured as the ratio of export to import prices. Barro (1997) argues that GDP growth can be achieved by a mechanism in which the change in the terms of trade stimulates a change in domestic employment and output. As can be seem in table 2.3, there is generally significant and positive association between the improvement of terms of trade and growth (Caselli, Esquivel and Lefort 1996; Barro 1997; Barro and Sala-i-Martin 2003).

A number of studies also examine openness, measured by the ratio of total trade to aggregate GDP. Most of them report a positive association between openness and GDP growth (Temple 1996 in Durlauf and Quah 1999). In contrast, Barro and Sala-i-Martin (2003) report an insignificant and positive association.

2.3.4.3.8 Other Variables

A large group of other variables are also extensively studied in growth regressions. Temple (1996) summarises most of the studies (Durlauf and Quah 1999). Amongst those variables, as shown in table 2.3, Barro (1997) and Barro and Sala-i-Martin (2003) find that democracy is good for GDP growth but at same point the benefits of democracy decrease with further democratic development. Barro and Lee (1994) and Caselli, Esquivel and Lefort (1996) report that the black market premium on foreign exchange is significantly negative associated with growth. Barro (1997) and Barro and Sala-i-Martin (2003) demonstrate that improvements in the rule of law are significantly and positively associated with growth. Barro and Lee (1994) and Caselli, Esquivel and Lefort (1996) suggest that revolution is significantly and negatively associated with growth. Caselli, Esquivel and Lefort (1996) report that assassination is significantly and negatively associated with growth. However, there is little variation in these variables across OECD countries.

2.3.5. Concluding Remarks

There are two major types of empirical study in the growth convergence literature. The first is based on the structural MRW model following Mankiw, Romer, and Weil (1992). It is commonly employed to test the specific augmented Solow model though it can also capture the convergence feature (Mankiw, Romer, and Weil 1992; Islam 1995; Caselli, Esquivel and Lefort 1996; and Temple 1998). The logic of its theoretical structure is to explain the complex phenomenon of growth with a limited number of key variables. Recently McDonald and Roberts (2002; 2005) extended the model to include health capital. But the overall theoretical structure of the MRW model has only limited empirical support. For example, in contrast to the striking finding of Mankiw, Romer and Weil (1992) that human capital is significantly and positively associated with growth, the latest studies provide mostly opposite evidence (Islam 1995; Caselli, Esquivel and Lefort 1996; and McDonald and Roberts 2005).

The second type of empirical study follows a general regression initiated by Barro and Sala-i-Martin (1992). It not only consistently captures the convergence feature but also accommodates a large group of explanatory variables (Barro and Sala-i-Martin 1992; Barro and Lee 1994; Barro and Sala-i-Martin 1995; Caselli, Esquivel and Lefort 1996; Barro 1997; and Barro and Sala-i-Martin 2003). The MRW model is in fact a specific one in the general regression. Most empirical studies, following the general regression model, report that the investment ratio, terms of trade, openness, rule of law, and democracy are significantly and positively associated with GDP growth. By contrast, inflation, the fertility rate, black market premium, revolution, and assassination are negatively associated with growth. However education, life expectancy, and general government consumption give inconsistent results across a number of studies.

This review raises at least three concerns in convergence literature. Firstly many theories suggest that human capital is critical to GDP growth, however, empirical studies have failed to provide consistent evidence. Secondly, earlier studies reported slow speeds of convergence, but recent studies, in particular, those using panel data methods, yield higher convergence coefficients. Third, when most existing studies focus on period data, few exploit annual data.

2.4. Suggestions for Research Topics

This literature review raises three research topics, which will be further addressed in the following chapters. Firstly, the significance of conventional growth accounting in the provision of the TFP growth rates is widely acknowledged, although there are serious criticisms of its failure to address the quality difference of inputs (Jorgenson and Griliches, 1967; Christensen, Cummings and Jorgensen 1980; 1981; Jorgenson, Gollop and Fraumeni, 1987). It is understandable that the decomposition of the conventional inputs is mainly restricted by data availability. For example Jorgenson and Griliches (1967) and Jorgenson, Gollop and Fraumeni (1987) were only able to conduct their growth accounting exercises for the USA because they were able to further decompose the conventional inputs. Due to the restrictions on data availability and accessibility, chapter three starts by examining the TFP growth rates of sixteen selected OECD, using the conventional growth accounting.

Barro (1999), Durlauf and Quah (1999), and Barro and Sala-i-Martin (2003) show that TFP encompasses a number of elements such as, labour augmented technological progress, capital augmented technological progress, and research and development. The implication is a regression of TFP on a number of explanatory variables suggested by theory. For example Griliches (1973) estimated the effect of an R&D variable on TFP. Coe and Helpman (1995), Keller (1998) Kao, Chiang and Chen (1999), and Edmond (2001) investigate the effect of domestic and foreign R&D capital stock on the level of TFP. Huffman and Evenson (1992, 1993, Ch.7) suggest a regression of agricultural TFP on a number of variables including stocks of public and private research, public investments in crop- and livestock-oriented extension, farmers' education, weather and regional variables. Thirtle (1999) presents a study of sugar productivity in the Eastern counties of England, relating it to R&D and weather. Following the literature, the second half of the next chapter will explore the association between the level of TFP, the R&D capital stock, a time trend, the capital stock, and openness.

Secondly there are a number of issues worth studying in the large convergence literature. Chapter four will follow the general regression suggested by Barro and Sala-i-Martin (1992), and extensively used by Barro and Lee (1994), Barro and Sala-i-Martin (1995), Caselli, Esquivel and Lefort (1996), Barro (1997), and Barro and Sala-i-Martin (2003). An immediate advantage of the general regression approach is the convenience of comparison with the large volume of empirical evidence available in the existing literature.

Chapter four will investigate the issues from several aspects. It will start with regressions of per capita GDP on a number of explanatory variables, using rarely employed annual data. The educational variables, reflecting human capital, will be excluded due to data availability. Instead they will be examined by auxiliary regressions using period average data, following the existing literature (Barro and Sala-i-Martin 1992, Mankiw, Romer and Weil 1992; Barro and Lee 1994; Islam 1995; Barro and Sala-i-Martin 1995; Caselli, Esquivel and Lefort 1996; Barro 1997; and Barro and Sala-i-Martin 2003). The regression on annual data is expected to provide consistent results, as is that on period data. However the analysis on annual data is based on more detailed information, which is therefore expected to yield richer and more reliable results.

Furthermore, chapter four will use the general framework of growth convergence to examine two further convergence mechanisms: capital stock convergence and TFP convergence. The first is to test the hypothesis that GDP convergence is equivalent to capital stock convergence (Barro and Sala-i-Martin 2003), and the second is to further examine the possible determinants of TFP growth.

Thirdly, chapter five will employ the growth convergence framework to investigate the economic performance of the transition economies in the last decade of the twentieth century. There are few theories which address that specific transition process characterised by a profound transformation from a centrally planned to a free market economy. Instead most available studies explore the economic performance by regressing real growth rate on a number of explanatory variables, including initial conditions, inflation, and a set of transition indicators (Merlevede 2003; Falcetti, Raiser and Sanfey 2002; Grogan and Moers 2001;

Aghion and Schankerman 1999; Brenton, Daniel and Guy 1997; De Melo et al. 1996; and Aghion and Blanchard 1994). Interestingly, initial conditions and the inflation rate are common variables in both the growth and transition literatures. They also behave consistently in most empirical studies, in which initial conditions and inflation are both significantly and negatively associated with growth (De Melo, Cevdet and Gelb 1996). For these reasons, this study will employ the general convergence framework to accommodate the empirical transition studies with per capita growth rate as dependent variable. Thus the empirical studies on transition economies will use a theory that is well established in the mainstream growth literature.

CHAPTER 3

GROWTH ACCOUNTING VERSUS REGRESSION IN A CROSS-COUNTRY TFP EXERCISE

SUMMARY: Conventional studies of the roles of total factor productivity (TFP) in economic growth are directly based on the results of growth accounting. This study further explores the determinants of TFP estimated from growth accounting for 16 selected OECD countries. This allows an investigation into TFP using an extensive data set. The first stage results from growth accounting support the view that TFP growth is by far the most important element in explaining GDP growth. This is consistent with the recent work of Klenow and Rodriguez-Clare (1997), Prescott (1998) and Easterly and Levine (2001). The second stage results from regressions of TFP on a number of explanatory variables, suggest that the foreign R&D capital stock in itself has no immediate benefit to domestic productivity. However the foreign R&D capital stock could enhance domestic productivity through trade. We also find that the time trend, reflecting exogenous technological progress, is a key element in explaining TFP progress.

KEY WORDS: Total Factor Productivity, Growth Accounting, Panel Data Method, Research and Development.

3.1. Introduction

Aggregate total factor productivity (TFP) has been widely discussed since Solow (1957) introduced a growth accounting approach. Following Solow (1957), Jorgenson and Griliches (1967), Christensen, Cummings, Jorgenson (1980; 1981), Jorgenson, Gollop, and Fraumeni (1987), Barro (1999), Romer (1995; 2001), Easterly and Levine (2001), and Barro and Sala-i-Martin (2003), TFP is interpreted as the contribution to growth of all factors except capital and labour. Alternatively, TFP can also be interpreted as a measure of ignorance (Mankiw, Romer, and Weil 1992; Hulten 2000). In either interpretation, TFP includes the impact of exogenous technological progress.

There is no conclusive evidence about the role of TFP. Most empirical studies (Barro and Sala-i-Martin, 1995; 2003; Klenow and Rodrigues-Clare, 1997; Prescott, 1998; Easterly and Levine, 2001) suggest that TFP has played an important role in growth. However, Young (1995) finds that the growth of TFP in the newly industrialised economies of East Asia: Hong Kong, South Korea, Taiwan, and especially in Singapore, was trivial during their key growth period 1966-1990. Much earlier, Jorgenson and Griliches (1967) argued that the USA's change rate of TFP during 1945-1965 tended to zero when factor inputs were further decomposed. By contrast, Jorgenson, Gollop and Fraumeni (1987) conclude that, for the USA, the contribution of capital input and labour input is greater than that of productivity growth in most years from 1949 to 1979. Given these conflicting views the question naturally arises: to what extent is TFP important, compared to labour and capital?

There are three concerns associated with growth accounting. The first is the perfectly competitive condition, which is necessary for Solow's definition of TFP.

Given perfect competition and constant returns to scale in a neo-classical production function, a factor's price is determined by its marginal productivity (Solow, 1956; 1957). Therefore the elasticity of output with respect to a factor input coincides with the factor's share in total output. This condition makes growth accounting defensible and applicable, but growth accounting itself does not reinforce it. Competition varies greatly across economies and periods, and is difficult to measure.

Recently, a dual approach to growth accounting that had originally been demonstrated by Jorgenson and Griliches (1967) was applied by Hsieh (1999; 2002). The approach is derived directly from the value equivalence between output and factor inputs, rather than from the neo-classical production function. The perfect competition condition appears to be relaxed (Hsieh, 1999; 2002; Barro, 1999; David Romer, 2001: 29-30; Barro and Sala-i-Martin, 2003). Hsieh (1999; 2002) recalculates the TFP growth rates in Young's 1995 exercise, using price side data. The results differ somewhat from Young's, especially in the Singaporean case, and the dispute continues (Klenow and Rodrigues-Clare, 1997; Young, 1998). However it appears that the competitive condition is ignored rather than relaxed, as under imperfect competition factor prices do not necessarily reflect real contributions to output (Jorgenson, Gollop and Fraumeni, 1987). In fact, the perfect competition condition is necessary to secure the equivalence between the price side accounting and the conventional growth accounting.

The second concern with growth accounting involves cross-section analysis. Growth accounting itself is a case-by-case approach that depends on a factor's output elasticity of production for each individual economy. As a result, information becomes fragmented and so the importance of local factors may be overestimated and the global picture distorted or lost. For instance Klenow and Rodrigues-Clare (1997) have argued that the apparent insignificance of TFP in the case of Singapore has no general economic implications because the example comes only from a city-state.

TFP is likely to reflect a range of causal growth links (Hulten, 2000; Easterly and Levine, 2001). It is hence probably a crucial mechanism or a bridge between those possible causes and growth. Barro (1999) and Barro and Sala-i-Martin (2003) examine several modified production functions and then suggest a number of accounting frameworks which employ a variety of additional variables. Some of these variables represent human capital, and research and development, which are extensively studied in the literature (Romer, 1986; Lucas, 1988; Romer, 1990; Mankiw, Romer and Weil, 1992; and Aghion and Howitt, 1992; 1998). Barro (1999) and Barro and Sala-i-Martin (2003) demonstrate that these variables are contained in the Solow TFP growth indices, through in practice it is impossible to account for them separately.

Thirdly most studies have interpreted the results of growth accounting by simply comparing the contribution of TFP growth to those of factor growth. However TFP growth indices are highly sensitive, particularly to input shares (Mankiw, 1995). A systematically biased approximation of input shares results in a systematically biased TFP estimate. In addition, TFP growth indices are also sensitive to the disaggregation of factor inputs. A substantial decomposition of factor inputs generally results in an less significant contribution from TFP growth (Jorgenson and Griliches, 1967; Jorgenson, Gollop and Fraumeni, 1987)

Nonetheless the significance of growth accounting is the provision of the primary information about the unobservable TFP growth index, also known as

Solow's residual. Given the significance of TFP growth suggested by neoclassical theories, it is empirically interesting to explore the determinants of TFP. The recent theoretical extension of growth accounting implies that TFP can be further explained by a number of variables, such as physical capital, R&D capital, and international trade.

Barro (1999) and Barro and Sala-i-Martin (2003), following growth accounting theory, show possible regressions of TFP growth on a number of variables. Unfortunately there are few empirical studies focusing on TFP growth. By contrast, existing studies focus on exploring the level of TFP associated with a number of variables, such as R&D capital stock, and international trade (Griliches 1973; Griliches and Lichtenberg 1984; Griliches 1986; 1988; Huffman and Evenson 1992; 1993; Griliches 1994; Coe and Helpman 1995; Keller 1998; Kao Chiang and Chen 1999; Thirtle 1999; Edmond 2001).

Based on the pioneering work of Coe and Helpman (1995), Keller (1998), Kao, Chiang and Chen (1999), and Edmond (2001), this chapter will re-examine the association of TFP with R&D capital stocks by introducing two new variables - a capital stock index and a trend term. The capital stock index captures the effect of externalities (Griliches 1979; Romer 1986; Lucas 1988; Barro 1999; and Barro and Sala-i-Martin 2003). The trend term reflects exogenous technological progress (Griliches 1973; Barro and Sala-i-Martin 2003). Both variables are surprisingly ignored by Coe and Helpman (1995), Keller (1998), Kao, Chiang and Chen (1999), and Edmond (2001), which possibly results in misspecification or biased estimates of the coefficients.

The organisation of the rest of the chapter is as follows. Section 1 sketches the theoretical background and basic methodology. The data is described in section 2, and the empirical results are presented and discussed in section 3. The key results are summarised in section 4.

3.2. Methodology

Neo-classical growth accounting, with Hicks-neutral technology, takes the following form[1]:

$$r^{TFP} = r^{Y} - \alpha \cdot r^{L} - \beta \cdot r^{K} \qquad (1)$$

where r^{TFP}, r^{Y}, r^{L} and r^{K} are the change rates of TFP, output, labour and capital input respectively. Given constant returns to scale $\alpha + \beta = 1$ and perfect competition, the elasticity and value share of an input are equal, so α and β are equal to the relatively easily measured input shares of labour and capital. In practice the perfect competition condition is never satisfied or tested.

The dual approach exploited by Hsieh (1999; 2002) uses a similar formula to equation (1), but appears to require less restrictive assumptions. This approach comes from the system equality between factor inputs and total output: $Y = w\ L + r\ K$ where w and r are respectively the prices of labour and capital inputs. A number of studies show that there are equivalent measures of productivity growth based on the dual relation between quantities and prices (Jorgenson and Griliches 1967; Christensen, Cummings and Jorgensen 1980; 1981; Jorgenson, Gollop and Fraumeni 1987; Huffman and Evenson 1993). After total differentiation and rearrangement we get:

$$r^{Y} - \alpha \cdot r^{L} - \beta \cdot r^{K} = r^{w} \cdot \alpha + r^{r} \cdot \beta \qquad (2)$$

[1] A growth rate is often approximated by a differentiation of the logarithmic term in empirical studies.

As can be seen, the left side of equation (2) is identical to the right side of equation (1). Thus Hsieh concentrates his attention on the right side of equation (2). Since the left-hand side is r^{TFP} in the neo-classical framework, provided the conditions are satisfied, the right hand side is automatically assumed to be equivalent to r^{TFP}, but without requiring the limiting restrictions of equation (1). Hsieh re-examines the work of Young (1995) and shows that the results from the two sides are not identical. We have strong reservations about an argument that the results from the right-hand side are more credible than those from the left-hand side. As price can fully reflect scarcity value only with perfect competition, the results from the right-hand side of (2) are also only approximations to the change rate of TFP under the assumption of perfect competition. That condition itself cannot be automatically relaxed.

In the majority of empirical studies (Barro and Sala-i-Martin, 1995; 2003; Young, 1995; Jorgenson et al., 1987; Christensen et al., 1980; 1981), the change in TFP is calculated using the logarithmic difference form – the translog specification presented in previous chapter - with the weights being the average of the factor shares in two successive periods. The logarithmic difference form is mathematically an approximation of equation (1) and therefore we use equation (1) directly with the input share measured as the average of two successive periods:

$$r^{TFP} = r^{Y} - \overline{\alpha} \cdot r^{L} - \overline{\beta} \cdot r^{K} \qquad (3)$$

where $\overline{\alpha} = \dfrac{\alpha(t) + \alpha(t-1)}{2}$ and $\overline{\beta} = \dfrac{\beta(t) + \beta(t-1)}{2}$

TFP growth can be computed from the above equation and later the average change rate over a period e.g. five years, ten years or the whole period, can be easily calculated. This is the first stage of the analysis based on the results directly from growth accounting. The interesting point here is that the average change rate of TFP currently attracts more attention than the annual figures in the conclusions based on growth accounting, even though the latter carry more information than the former.

The second stage of our study investigates the determinants of TFP, following Coe and Helpman (1995), Keller (1998), Kao, Chiang and Chen (1999), and Edmond (2001). The theoretical foundation rests on endogenous growth theories (Romer 1990; Grossman and Helpman 1991: ch.3. and ch.4.; Aghion and Howitt 1992; Coe and Helpman 1995; and Barro 1999). Most importantly, the feasibility of such an analysis is largely due to the availability of the R&D capital stock data established by Coe and Helpman (1995). This data has been used in a number of studies (Keller 1998; Kao, Chiang and Chen 1999; and Edmond 2001).

Keller (1998), Barro (1999), and Barro and Sala-i-Martin (2003) sketch the underlying theory based on the works of Romer (1990), Grossman and Helpman (1991) and Aghion and Howitt (1992). The theoretical foundation is derived from a specific production function following Romer (1990) and Grossman and Helpman (1991, ch.3). The production function reflects the horizontal expansion of the product-varieties of intermediate capital goods.

$$Y = AL^{1-\alpha}\sum_{i=1}^{N} x_i^{\alpha} \qquad 0<\alpha<1 \qquad (4)$$

where L is labour input, x_i is the intermediate capital goods of type i. N is the total number of varieties of intermediate goods, and Y is output.

In equilibrium, each intermediate good is used in the same quantity, x, and hence:

$$x = x_i = \frac{1}{N}\sum_{i=1}^{N} x_i = \frac{X}{N} \qquad (5)$$

where X is the sum of intermediate goods. X is the flow of services from the aggregate capital stock if all x_i are non-durable goods. Equation (4) can be rewritten as:

$$Y = AL^{1-\alpha} N^{1-\alpha} X^{\alpha} \qquad (6)$$

This implies that technological progress can result from R&D expenditure over varieties of intermediate goods. Given that the variable N reflects the current level of technology, the leading technology encompasses all N varieties of intermediate goods available. This model is thus the best for general technologies (David 1991; Bresnahan and Trajtenberg, 1995; and Barro, 1999). Assuming that equation (6) exhibits constant returns in capital goods and labour inputs and that both labour and intermediate capital goods receive their marginal products, the elasticity of factor input coincides with its input share.

$$\alpha = s_X = 1 - s_L \qquad (7)$$

In contrast to the framework of growth accounting suggested by Barro (1999) and Barro and Sala-i-Martin (2003), an index of TFP is defined as:

$$LnTFP = \ln Y - \alpha \cdot \ln X - (1-\alpha) \cdot \ln L \qquad (8)$$

Huffman and Evenson (1992) call the above growth accounting the first stage analysis of a "two-stage decomposition analysis". The second stage analysis is a typical regression analysis of *ln*TFP with respect to a number of variables.

Barro (1999) illustrates a positive relationship between *Ln*TFP and the range of varieties of intermediate goods as:

$$LnTFP = \ln A + (1-\alpha) \cdot \ln N \qquad (9)$$

International trade enables both domestic and foreign intermediate goods to be employed. Coe and Helpman (1995) separate the foreign from the domestic range of intermediate goods, which together make up what they call the R&D capital stock. As a result, equation (9) can be rewritten as:

$$LnTFP = \beta_0 + \beta_1 \ln S^d + \beta_2 \ln S^f + \varepsilon \qquad (10)$$

where $\beta = ln$A, S^d is the cumulative stock of domestic R&D expenditure, and S^f is that of foreign R&D expenditure. Clearly the coefficients β_2, and β_3 are respectively the elasticity of TFP with respect to domestic and foreign R&D expenditures.

To examine the effects of the trade-related R&D spillovers (Grossman and Helpman 1991, Section 6.5), Coe and Helpman (1995) introduce an additional explanatory variable, m· S^f, to capture the role of international trade, where m is import share.

$$LnTFP = \beta_0 + \beta_1 \ln S^d + \beta_2 \ln S^f + \beta_3 (m \cdot \ln S^f) + \varepsilon \qquad (11)$$

In the literature (Coe and Helpman 1995; Keller 1998; Kao, Chiang and Chen 1999; and Edmond 2001), equations (10) and (11) are specified as one-factor panel data models:

$$LnTFP_i = \beta_{0,i} + \beta_1 \ln S^d + \beta_2 \ln S^f + \beta_3 (m \cdot \ln S^f) + \varepsilon \qquad (12)$$

Based on equations (10), (11), and (12), Coe and Helpman (1995) and Kao, Chiang and Chen (1999) show that the coefficients β_1, β_2, and β_3 are all significantly positive. These results seem to support two hypotheses. The first one is the import composition effect, i.e. one country is expected to achieve higher productivity if importing from others which have higher levels of technological knowledge. The second is the overall import share effect, i.e. for a given composition of imports, the higher the import share of an economy, the more the economy can gain from foreign accumulation of R&D stock (Keller 1998).

However, the results are challenged by Keller (1998) and Edmond (2001). Keller (1998) shows that randomly generated trade patterns also lead to positive international R&D spillover estimates. While Edmond (2001) found that the elasticity of productivity with respect to foreign R&D is unstable across alternative specifications.

This study extends the existing framework by adding two interesting variables, capital stock indices and a trend term. The capital stock variable helps to capture the effect of externalities (Griliches 1979; Romer 1986; Lucas 1988; Barro 1999; and Barro and Sala-i-Martin 2003). The trend term, reflecting exogenous technological progress (Griliches 1973; Barro and Sala-i-Martin 2003), is a specific time effect. Time effects can generally be captured by time dummies in a two-factor panel data analysis.

3.3. Panel data analysis

Panel data methods are the preferred technology for pooled cross-country and period analysis (Durlauf and Quah, 1999; Temple, 1999), since panel data provide more information, more efficiency and less multi-collinearity (Baltagi, 1999; 2005). Baltagi (2005) and Wooldridge (2002) summarise the core technologies and issues in terms of econometric methodology. Greene (2002) presents more accessible illustrations of its applications. Appendix A sketches the technical detail of the panel data analysis and corresponding test statistics employed in this thesis, except for panel cointegration tests which are presented later. This chapter applies both one-factor and two-factor panel data approaches. A cross-country panel data regression with two-factor error components has double indices on its variables so that:

$$LnTFP_{i,t} = \beta_0 + \beta_1 \ln S^d + \beta_2 \ln S^f + \beta_3 (m \cdot \ln S^f) + u_{i,t} \quad (13)$$

$$i = 1, 2, \ldots, N \text{ and } t = 1, 2, \ldots, T$$

where i denotes countries, t denotes periods and $u_{i\,t}$ can be decomposed into a two-factor error components disturbance model:

$$u_{i,t} = d_i + d_t + v_{i,t} \quad (14)$$

$$i = 1, 2, \ldots, N \text{ and } t = 1, 2, \ldots, T$$

where d_i indicates the unobservable individual country effect while d_t indicates the associated unobservable time effect, and $v_{i,t}$ is the remaining independent stochastic error term. In this specification, d_i is time invariant and accounts for an individual country specific effect that is not included in the regression. d_t is country invariant and accounts for any time specific effect excluded from the regression. Treating error components for d_i and d_t differently results respectively in fixed effects and random effects models.

In the fixed effects case, $v_{i,\,t}$ is the only independent stochastic error term while both d_i and d_t are assumed to be fixed parameters – those are dummies that can be estimated in the model. This specification introduces more individual dummies and possibly suffers from the consequent loss of degrees of freedom. The parameters of interest can be estimated by least squares dummy variables (LSDV). One of the disadvantages of this approach is that any other country-invariant or time-invariant variables such as race, religion, geographical location, regional crisis, economic club or group cannot be exploited. On the other hand, too many dummies might increase the risk of multi-collinearity.

The random effects model treats both d_i and d_t as well as $v_{i,\,t}$ as stochastically independent disturbances. Thus the relative effects of the unobservable country and time dummies, as well as the variance of the error term, can be estimated and compared. The attractive aspect of this approach is that country or time invariant factors can be investigated via dummies. The model can be estimated by Generalised Least Squares (GLS). Although the random effects model appears to have some appealing properties it is not statistically superior to the corresponding fixed effects model. In practice, a comparison could be made using Hausman's LM chi-squared statistic (Hausman, 1978). A large value of the Hausman statistic favours the fixed effects model over the random one.

There are various test statistics for model selection within the panel data approaches. Econometricians generally favour two likelihood test statistics: the Lagrange Multiplier (LM) and the Likelihood Ratio (LR) tests, which are asymptotically equivalent to an F-test when the null hypothesis is true. Within a panel data analysis, LR, LM and an F test have been used for model selection between OLS and LSDV, i.e. test of fixed effects. Second, the LM test can be used to decide between OLS and random effects models, i.e. test of random effects. Third, Hausman's LM statistic, as noted above, is used for selection between fixed and random effects models.

One feature of model (13) is that TFP, domestic and foreign R&D capital stocks all exhibit a clear upward trend over time (Coe and Helpman 1995; Kao, Chiang and Chen 1999; and Edmond 2001). To avoid the possible spurious correlation problem due to non-stationary data, panel cointegration tests are suggested by Coe and Helpman (1995), and substantially updated by Kao, Chiang and Chen 1999 and Edmond (2001). Following Kao (1999), Kao, Chiang and Chen (1999), Kao and Chiang (2000), and Pedroni (2000; 2004), residual-based Dickey-Fuller (DF) and augmented Dickey-Fuller (ADF) tests can be computed from the fixed effects residuals of model (13).

$$\hat{v}_{i,t} = \gamma \hat{v}_{i,t-1} + \varepsilon_{i,t} \tag{15}$$

To test for the panel cointegration relationship of model (13), the null and alternative hypotheses are respectively:

$H_0: \gamma = 1.$

$H_1: \gamma \neq 1.$

The OLS estimate of γ and the t-statistic are given as:

$$\hat{\gamma} = \frac{\sum_{i=1}^{N} \sum_{t=2}^{T} \hat{v}_{i,t} \hat{v}_{i,t-1}}{\sum_{i=1}^{N} \sum_{t=2}^{T} \hat{v}_{i,t}^{2}} \tag{16}$$

$$t_{\gamma} = \frac{(\hat{\gamma} - 1)\sqrt{\sum_{i=1}^{N} \sum_{t=2}^{T} \hat{v}_{i,t} \hat{v}_{i,t-1}}}{\sqrt{\frac{1}{NT} \sum_{i=1}^{N} \sum_{t=2}^{T} (\hat{v}_{i,t} - \hat{\gamma} \cdot \hat{v}_{i,t-1})^{2}}} \tag{17}$$

Accordingly, Kao (1999), Kao, Chiang and Chen (1999), and Kao and Chiang (2000) suggest four DF and one ADF-type tests, in which two DF-type tests are given as:

$$DF_{\gamma} = \frac{\sqrt{N}\left[T(\hat{\gamma} - 1) + 3\right]}{\sqrt{10.2}} \overset{converge}{\sim} N(0,1) \tag{18}$$

$$DF_{t} = \sqrt{1.25} t_{\gamma} + \sqrt{1.875N} \overset{converge}{\sim} N(0,1) \tag{19}$$

Above all, the various panel data approaches reduce the risks caused by methodological problems. Panel data technology is also generally more efficient than OLS. So from now on we pay more attention to the empirical methodology and results, than to theoretical econometric problems.

3.4. Data description and capital stock estimation

The principal data is derived from World Bank (2000), and European Commission (2002). It covers sixteen OECD countries including Austria, Belgium, Denmark, Greece, Finland, France, Ireland, Italy, Japan, Luxembourg, Netherlands, Portugal, Spain, Sweden, the United Kingdom, and the United States of America. Germany is excluded for data limitations due to reunification. The choice of countries is dictated by data availability and accessibility. The data series run from 1960 to 1997 and total observations are 592.

The GDP growth rates are from the World Bank, based on real GDP in local currency (World Bank, 2000). The growth rates of real labour input are based on the adjusted labour input calculated from the labour force multiplied by the unemployment rate. Labour forces are the total labour force of the economically active population, from World Bank (2000). Unemployment rates and labour shares are from the European Commission (2002). Labour shares are adjusted wage shares defined as the compensation per employee as a percentage of GDP at factor cost per person employed.

The domestic and foreign research and development capital stocks are constructed by Coe and Helpman (1995). The domestic R&D capital stock is the estimate of business sector research and development capital stocks based on R&D

expenditure. The foreign R&D capital stock is constructed as a weighted sum of the cumulative R&D expenditures of the country's trading partners in which the weights are given by the bilateral import shares. This data is unavailable for Luxembourg which is thus excluded from the second stage of the study. The data series run from 1971 to 1990 and total observations are 300.

The capital stock series are created from the real gross domestic fixed investment data from the World Bank (2000). Data on the real capital stock or constant price capital accumulation are seldom directly available, even in well-documented economies. Fortunately it can be estimated from annual constant price investment data, assuming a fixed depreciation rate. This method is widely used and the appropriate equation is:

$$K_t = (1-\delta_t) \cdot K_{t-1} + I_t \qquad (20)$$

where K_t and I_t are respectively the accumulated capital stock and investment, and δ_t is the 5% assumed annual depreciation rate. However the initial capital stock, K_0, is unknown and it is sometimes suggested that a rough estimate is adequate, provided we have reasonably accurate investment data, because depreciation will progressively reduce the influence of any original inaccuracy (Barro and Sala-i-Martin, 1995; 2003). A majority of recent researchers (Easterly and Levine, 2001; Abdelhak Senhadji, 2001; Susan M. Collins and Barry P. Bosworth, 1996) use previous studies' initial capital stock, estimated from investment data back to 1950 (Robert G. King and Ross Levine, 1994; Vikram Nebru and Ashok Dhareshwar, 1993).

For this study, we suggest an alternative three-stage approach to creating initial capital stock data. We assume there is a fixed local ratio between investment and the capital stock. This is probably not strictly constant but follows a probability distribution. In the first stage, given a rough estimate of the initial capital stock – for example ten times the value of investment – we calculate the capital stock for subsequent years by equation (20). The second stage uses the derived data to estimate the ratio of investment to capital accumulation, which is then re-used to estimate a new initial K_0, and a new series for the capital stock. The revised series will be more accurate than the first, but still capable of improvement. The third stage then involves further repetitions of stage two, and in practice the process converges rapidly.

The rationale for this three-stage procedure can be seen from the following transformation based on equation (20):

$$\frac{K_t}{K_{t-1}} = (1 - \delta_t) \cdot (1 - \frac{I_t}{K_t})^{-1} \tag{21}$$

This equation illustrates the relationships amongst the ratio of investment to the capital stock, the capital depreciation rate, and the change rate of the capital stock. A lower depreciation rate and higher ratio of investment to the capital stock lead to a faster accumulation rate. If the depreciation rate δ_t is constant and simultaneously K_t changes at a constant rate, the ratio between investment and the capital stock remains constant. It is very likely that the capital stock grows around a constant rate. Meanwhile the depreciation rate is often assumed to be constant around 0.05. Thus the ratio of investment to capital stock is likely to be constant.

It would appear that the above assumption violates the law of diminishing returns to capital. But it is in fact difficult to observe diminishing returns at a macro rather than at a micro level. Robert E. Lucas Jr. (1988, 2002) based on the work of Edward F. Denison (1961), reveals that the US capital stock during 1909-1957 experienced a stable growth rate of 2.4 percent. So it is reasonable to expect a constant return over a period of several decades.

The assumption of a constant ratio between investment and the capital stock can be empirically tested after the capital stock series are constructed. Such a test, without a loss of generality, is conducted via panel data methods in which capital stock data are generated according to the suggested three-step approach. The test results are summarised in table 3.1, when the two different samples from OECD countries are pooled. As can be seen, the ratios estimated from both databases are extremely significant, while the constant terms are not. The R-squared for this relationship exceeds 97% for both samples. These results support the assumption.

Table 3.1 - TESTING THE RATIO BETWEEN INVESTMENT AND CAPITAL STOCK

Sample	16 OECD	OECD*
Ratio	13.953 (67.43)	13.950 (79.78)
Constant term	$1.43\text{x}10^{11}$ (0.601)	$-1.04\text{x}10^{13}$ (0.611)
R^2	0.9778	0.9783
Observations	592	813

Two way LSDV panel data is used. The dependent variable is the capital stock, while the explanatory variable is investment, and a constant term is included.

Ratio is equivalent to the coefficient of investment and the t-values are in parentheses.

OECD* consists of 22 countries, namely Australia, Austria, Belgium, Canada, Denmark, Finland, France, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, UK and USA.

For a more detailed description of the data, see appendix B. The statistical descriptions of the data are presented in appendix C. The graphic descriptions of the data are presented in appendix D.

3.5. Results and implications

3.5.1. Results of growth accounting – the first stage analysis

Table 3.2 presents the growth accounting results for 16 individual OECD countries. As can be seen, on average TFP growth contributes 58 per cent of GDP growth. By contrast, capital stock and labour growth contribute 27 per cent and 15 per cent of GDP growth respectively. This suggests that TFP contains the bulk of ignored factors explaining general economic growth.

Across countries, the USA is unique for its slow TFP progress, less than one per cent, and for the lowest growth contribution from TFP progress: 31 per cent during the period. This figure might well reflect the general technological leadership of the USA. For it is mostly genuine research and innovation that drive TFP progress in the USA. Other countries, as followers in general, can achieve relatively higher TFP progress by technological imitation and transfer at much lower cost. The chances of imitation and transfer for a technological leading country are clearly much less than for follower states.

Japan is another interesting economy, with the highest rate of TFP progress, almost three per cent annually, though the average contribution of Japanese TFP progress is well below the average. The Japanese economic miracle during the 1960s, 1970s and 1980s of the studied sample period is indeed widely believed to have benefited from technological upgrade mainly by imitation, though capital accumulation also contributes to more than 30 per cent of its general economic growth.

Table 3.2 - GROWTH ACCOUNTING FOR 16 OECD COUNTRIES DURING 1960-97

Country (labour share)	Growth Rate of GDP	Contribution from labour growth	Contribution from capital growth	TFP growth
Austria (72.52%)	0.0326	0.0021 (6%)	0.0092 (28%)	0.0213 (66%)
Belgium (72.51%)	0.0304	0.0022 (7%)	0.0082 (27%)	0.0200 (66%)
Denmark (71.89%)	0.0288	0.0058 (20%)	0.0072 (25%)	0.0157 (55%)
Greece (75.03%)	0.0412	0.0048 (12%)	0.0105 (25%)	0.0259 (66%)
Finland (72.74%)	0.0329	0.0027 (8%)	0.0080 (24%)	0.0222 (69%)
France (73.78%)	0.0329	0.0036 (11%)	0.0081 (25%)	0.0213 (65%)
Ireland (73.34%)	0.0476	0.0053 (11%)	0.0127 (27%)	0.0295 (65%)
Italy (74.56%)	0.0334	0.0029 (9%)	0.0053 (16%)	0.0252 (76%)
Japan (73.71%)	0.0550	0.0079 (14%)	0.0173 (31%)	0.0298 (54%)
Luxembourg (63.98%)	0.0382	0.0051 (13%)	0.0152 (40%)	0.0179 (46%)
Netherlands (68.71%)	0.0323	0.0100 (31%)	0.0076 (24%)	0.0147 (46%)
Portugal (75.28%)	0.0432	0.0062 (14%)	0.0126 (29%)	0.0243 (54%)
Spain (72.26%)	0.0413	0.0029 (7%)	0.0137 (33%)	0.0247 (61%)
Sweden (71.53%)	0.0248	0.0056 (23%)	0.0061 (24%)	0.0132 (53%)
UK (73.26%)	0.0236	0.0029 (12%)	0.0068 (29%)	0.0138 (59%)
USA (72.51%)	0.0307	0.0117 (38%)	0.0096 (31%)	0.0094 (31%)
Average (72.35%)	0.0356	0.0051 (15%)	0.0099 (27%)	0.0206 (58%)

The numbers in parentheses of columns two to four are the percentage of the GDP growth rate explained by the corresponding factor and TFP growth.

Following Japan, three countries, Ireland, Greece, and Italy achieved average TFP progress of over 2.5 per cent. By contrast, Sweden, the UK, the Netherlands, Denmark, and Luxembourg are well below the average TFP progress for the whole sample, which is around 2 per cent. These results perhaps suggest that Ireland, Greece, and Italy benefited more from technological imitation and transfer than do Sweden, the UK, the Netherlands, Denmark, and Luxembourg. The next chapter will further examine the TFP convergence mechanism.

3.5.2. Results of TFP regressions – the second stage analysis with one-way panel data specification

After the first stage of calculating the TFP index from a growth accounting exercise, table 3.3 presents the second stage results for alternative regressions of TFP, based on a one-way fixed country-effect panel data method. As can be seen, F-tests suggest that the fixed country effects are jointly significant. Hausman's tests generally favour the fixed-effect rather than the random-effect model. Kao's Dickey-Fuller tests do not reject the existence of panel cointegrations for alternative regressions.

M3.1 presents one of the core specifications suggested by Coe and Helpman (1995). It has been repeatedly examined by Keller (1998); Kao, Chiang and Chen (1999); and Edmond (2001). As shown, M3.1 reports significant and positive coefficients on all three explanatory variables. It seems to suggest that foreign R&D has immediate beneficial effects on domestic productivity, which is further enhanced by openness. The immediate effect is captured by the positive coefficient on ln(foreign R&D stock) while the enhancement by openness is indicated by the interactive variable between openness and ln(forign R&D stock) (see (11) above).

The coefficient on the interactive term measures the marginal effect of the foreign R&D capital stock, as an economy becomes more open. This is the major finding of Coe and Helpman (1995). Inclusion of openness as a separate variable in the alternative specification M3.2 does not alter the results of M3.1. The coefficient on openness is reported significantly positive, which is expected. The coefficients on the two R&D variables also seem to show that the elasticity of TFP with respect to the domestic R&D capital stock is higher than for the foreign R&D capital stock.

Table 3.3 - ALTERNATIVE SPECIFICATIONS FOR TFP WITH FIXED COUNTRY EFFECTS

Explanatory variables		Specification with ln(*TFP*) as dependent variable				
		M3.1	**M3.2**	**M3.3**	**M3.4**	**M3.5**
Type of Sample (observations)		Annual frequency (1971-1990) (300)				
Ln (domestic R&D stock)		0.120 (11.67)***	0.114 (10.99)***	0.0085 (0.773)	-0.039 (3.278)***	-0.333 (0.252)
Ln (foreign R&D stock)		0.086 (2.963)***	0.077 (2.637)***	-0.143 (5.200)***	-0.186 (7.251)***	-0.080 (2.890)***
Time trend (exogenous technological progress)		--	--	0.0162 (13.93)***	0.0122 (10.29)***	--
Openness (Import/GDP)		--	0.201 (2.426)**	-0.024 (0.358)	-0.101 (1.666)*	-0.0121 (0.172)
Ln (capital stock)		--	--	--	0.252 (7.631)***	0.403 (11.64)***
Ln (foreign R&D stock) * (Import/GDP)		0.220 (2.626)***	0.231 (2.767)***	0.205 (3.199)***	0.280 (4.719)***	0.340 (4.912)***
Adjusted R^2		0.7165	0.7213	0.8348	0.8628	0.8115
F-test of fixed country effects		11.50 (0.000)	11.91 (0.000)	9.31 (0.000)	9.05 (0.000)	13.80 (0.000)
Hausman's test of random country effects		8.59 (0.035)	11.72 (0.020)	--	--	10.94 (0.053)
Kao's Dickey-Fuller test of panel cointegration	DF_ρ	2.016 (0.041)	2.608 (0.009)	2.048 (0.028)	2.005 (0.035)	2.006 (0.036)
	DF_t	14.93 (0.000)	15.49 (0.000)	15.29 (0.000)	14.45 (0.000)	14.46 (0.000)

One-way LSDV is employed to estimate models. For estimated coefficients, t-statistics in parentheses with * significant at 10%, ** at 5% and *** at 1%. For test statistics, p-values are presented in parentheses. Appendix L presents the detailed results of regressions and tests of M3.1.

However, the results of M3.1 and M3.2 are conditioned on the absence of other variables, in particular the time trend and capital stock. The first is widely recognised as a key element representing exogenous technological progress, and the second can capture the effects of externalities (Griliches 1973; 1979; Barro and Sala-i-Martin 2003). Ignoring these two variables likely results in misspecification or biased estimates of other explanatory variables. Clearly it is necessary to check whether the results are consistent with the inclusion of these variables.

Surprisingly, the presence of a trend term – a variable reflecting exogenous technological progress - alters the story revealed by M3.1 and M3.2. As can be seen from M3.3 in which a trend term is added, the coefficient on domestic R&D capital stock becomes insignificant and the coefficient of foreign R&D capital stock is now significantly negative. There is no immediate theoretical explanation for this significantly negative coefficient. Intuitively, the negative coefficient might suggest that the increase of foreign R&D capital stock had no immediate beneficial effect for an economy. Instead the increase in the foreign R&D capital stock perhaps undermines the relative domestic technological position of an economy due to international competition, and hence relatively damages the domestic productivity. This argument however is highly speculative.

In contrast, the coefficients on the trend term and interactive term between foreign R&D capital stock and openness are significant and very robust. The positive coefficient on the trend term emphasises the important role of exogenous technological progress in domestic productivity. And as noted above, the coefficient on the interactive term measures the marginal effect of the foreign R&D capital stock, as an economy becomes more open. The positive coefficients suggest that domestic productivity marginally benefits from the foreign R&D capital stock when the import ratio to GDP increases, though neither the foreign R&D capital stock nor openness has immediate benefit to domestic productivity. These results are consistent even if the second variable, domestic capital stock is added. More surprisingly, adding the capital stock variable results in significant and negative coefficients on both domestic and foreign R&D capital stock. There are no obvious theoretical and intuitive explanations for these results. However, these unexpected results do suggest that the major finding of Coe and Helpman (1995) is at least not robust.

It is worth further examining the sensitivity of the above co-integration results to the inclusion of lagged variables when time series data are employed. (An alternative econometric model addressing this issue is the equilibrium correction mechanism, see D. Hendry 1995: p 286-294). Table 3.4 reports the results for alternative specifications in which a lagged dependent variable and two lagged explanatory variables are included. The lagged explanatory variables are the counterparts of domestic and foreign R&D stocks. As can be seen, all the coefficients in table 3.4 are robust across alternative specifications, but the explanation of these results is not always easy. First, the coefficients on the lagged dependent variable are significantly positive and their values are close to unity. This suggests that the current level of TFP largely depends on its immediate past.

Second, the coefficients on current and lagged domestic R&D capital stocks are all insignificant with respectively positive and negative signs. The positive coefficients on the current one are consistent with that of M3.3 in which a time trend is included. The sum of the coefficients on current and lagged variables is largely cancelled out, as their absolute values are very close to each other. This suggests that the domestic R&D capital stock has no significant impact on the domestic TFP.

Table 3.4 - ALTERNATIVE SPECIFICATIONS FOR TFP WITH LAGGED VARIABLES

Explanatory variables	Specification with ln(*TFP*) as dependent variable				
	M4.1	**M4.2**	**M4.3**	**M4.4**	**M4.5**
Ln (TFP) lagged one period	0.900 (33.60)***	0.906 (33.42)***	0.848 (25.75)***	0.829 (22.83)***	0.875 (26.78)***
Ln (domestic R&D stock)	0.102 (1.198)	0.0881 (1.031)	0.0289 (0.334)	0.0305 (0.353)	0.0850 (0.998)
Ln (domestic R&D stock) lagged one period	-0.0934 (1.145)	-0.0797 (0.971)	-0.0323 (0.393)	-0.0386 (0.469)	-0.0839 (1.025)
Ln (foreign R&D stock)	-0.0768 (3.249)***	-0.0743 (3.138)***	-0.0866 (3.661)***	-0.0915 (3.822)***	-0.0819 (3.413)***
Ln (foreign R&D stock) lagged one period	0.0806 (3.668)***	0.0798 (3.636)***	0.0621 (2.775)***	0.0596 (2.655)***	-0.0749 (3.394)***
Time trend (exogenous technological progress)	--	--	0.0026 (3.027)***	0.0024 (2.795)***	--
Openness (Import/GDP)	--	-0.0005 (1.373)	-0.0007 (1.991)**	-0.0008 (2.151)**	-0.0006 (1.650)
Ln (capital stock)	--	--	--	0.0294 (1.278)	0.0394 (1.712)*
Ln (foreign R&D stock) * (Import/GDP)	0.0455 (1.284)	0.0422 (1.192)	0.0520 (1.481)	0.0627 (1.742)*	0.0576 (1.580)
Adjusted R^2	0.9482	0.9484	0.9500	0.9501	0.9487
F-test of fixed country effects	1.238 (0.247)	1.315 (0.198)	0.929 (0.528)	1.048 (0.406)	1.533 (0.099)
Hausman's test of random country effects	12.66 (0.049)	13.36 (0.064)	7.69 (0.464)	12.12 (0.207)	15.30 (0.054)

One-way LSDV is employed to estimate models. For estimated coefficients, t-statistics in parentheses with * significant at 10%, ** at 5% and *** at 1%. For test statistics, p-values are presented in parentheses. Appendix L presents the detailed results of regressions and tests of M4.1.

In contrast, the coefficients on current and lagged foreign R&D stocks are all significant, but with negative and positive signs respectively. The significant negative coefficients on current foreign R&D capital stocks are consistent with M3.3, M3.4 and M3.5 when at least a time trend or physical capital stock is included. As the absolute values of the coefficients on current and lagged ones are again very close to each other, the sum of them is again largely cancelled out. We cannot conclude that the overall impact of the foreign R&D on domestic TFP is significant. It is rather difficult to explain why the immediate and previous effects of foreign R&D stock are respectively negative and positive. However, the above results further undermine the findings of Coe and Helpman (1995).

Third, the coefficients on the time trend are significant and positive, which is consistent with the results in table 3.3. As the time trend represents the exogenous technological progress, these results confirm the positive role of exogenous technological progress in increasing TFP. However, the coefficients on openness are negative. They are consistent with the results of M3.3, M3.4, and M3.5 where a time trend and physical capital stock are included. There is no obvious explanation for this. Finally, the coefficients on domestic capital stock and the interaction term are all positive, though not significant in some regressions. The positive coefficients are consistent with the results in table 3.3.

Above all, the coefficients on three variables – the time trend, domestic capital stock, and the interaction term between foreign R&D capital stock and openness, are consistent through all the specifications. The first one suggests the significance of exogenous technological progress. The second shows the externality effects. The third indicates that domestic productivity can receive a marginal benefit from the foreign R&D capital stock, through foreign trade. In contrast, we cannot find consistent evidence backing the argument that the domestic and foreign R&D capital stocks can directly enhance domestic TFP.

3.5.3. Extension of the second stage analysis with two-way panel data specification

It is worth examining the time-effect in a less restrictive way with two-way panel data methods, as the results in table 3.3 suggests a time trend is significant.

Table 3.5 presents alternative regressions, in which M5.2 and M5.3 are respectively corresponding to M3.2 and M3.5. As can be seen, F-tests suggest that fixed time effects are jointly significant. Hausman's tests favour fixed-effect rather than random-effect panel data specifications.

Table 3.5 - ALTERNATIVE SPECIFICATIONS WITH FIXED COUNTRY AND PERIOD EFFECTS

Explanatory variables	Specification with ***TFP*** as dependent variable		
	M5.1	**M5.2**	**M5.3**
Type of Sample (observations)	Annual frequency (1971-1990) (300)		
Constant	-0.066 (11.06)***	-0.039 (1.521)	-0.021 (0.890)
Ln (domestic R&D stock)	0.010 (0.858)	0.009 (0.819)	-0.040 (3.291)***
Ln (foreign R&D stock)	-0.133 (4.674)***	-0.140 (4.790)***	-0.174 (6.463)***
Openness (Import/GDP)	--	-0.090 (1.049)	-0.087 (1.110)
Ln (capital stock)	--	--	0.263 (7.399)***
Ln (foreign R&D stock) *(Import/GDP)	0.233 (3.504)***	0.239 (3.581)***	0.287 (4.688)***
Adjusted R^2	0.8336	0.8337	0.8620
F-test of fixed time effects	14.47 (0.000)	14.36 (0.000)	11.36 (0.000)
Hausman's test of random country and time effects	8.54 (0.036)	10.58 (0.032)	6.398 (0.045)

Two-way LSDV is employed to estimate models. For estimated coefficients, t-statistics in parentheses with * significant at 10%, ** at 5% and *** at 1%. For test statistics, p-values are reported in parentheses. Appendix L presents the detailed results of regressions and tests of M5.1.

Comparing the results in table 3.5 with those in table 3.3, two variables – domestic capital stock and interaction between foreign R&D capital stock and openness, are again consistent through alternative methods. Meanwhile the significance of fixed time-effects in table 3.5 reflects the importance of time dummies, which are specified as a trend variable in table 3.3. By contrast, the coefficients of domestic and foreign R&D capital stock in table 3.5 have very few differences with their correspondences in table 3.3. Clearly, the main results revealed by the one-way panel data method are well preserved in the alternative two-way panel data model.

3.5.4. Country and time dummies

It is interesting to investigate country and time variation when fixed-effect panel data methods are employed. These variations reflect the corresponding fixed effects unexplained by the explanatory variables. They are likely to be sensitive to model specifications and hence do not always provide consistent results.

Tables 3.6 and 3.7 report respectively coefficients of countries' dummies corresponding to the alternative estimates of tables 3.3 and 3.5. As can be seen, the significance of dummy variables, for a particular country, is generally sensitive to model specifications. These are expected except for those reported in M3.3 and M3.4 associates of table 3.6. The unusual results of the estimate of the coefficients and t-statistics have clearly resulted from the inclusion of a trend term, which is invariant across countries in the one-factor panel data analysis. It suggests an alternative investigation of time effects by a two-factor panel data regression is needed, in which less restriction is imposed on time effects.

Indeed, table 3.8 reports coefficients on time dummies, and provides some striking results. As can be seen, the estimates of coefficients on time effects in all the three specifications exhibit consistent and significant upward trends, which is unexpected. However, it strongly indicates the significance of the trend term that is improperly ignored by Coe and Helpman (1995). These results strongly emphasise the significance of a trend term in the determinants of TFP.

Table 3.6 - VARIATION OF COUNTRY DUMMIES ASSOCIATED WITH ONE-WAY PANEL DATA SPECIFICATIONS

	M3.1 associate			M3.2 associate			M3.3 associate			M3.4 associate			M3.5 associate		
	Coefficient	S.E.	t-ratio	Coefficient	S.E.	t-ratio	Coefficient	S.E.	t-ratio	Coefficient	S.E.	t-ratio	Coefficient	S.E.	t-ratio
Belgium	-0.013	0.012	-1.103	-0.136	0.052	-2.611	-32.22	2.30	-13.98	-24.17	2.35	-10.29	-0.007	0.044	-0.153
Denmark	-0.044	0.011	-3.968	-0.112	0.030	-3.711	-32.24	2.31	-13.98	-24.22	2.35	-10.30	-0.043	0.026	-1.696
Greece	0.048	0.013	3.662	-0.004	0.025	-0.140	-32.21	2.31	-13.93	-24.18	2.35	-10.27	0.040	0.021	1.946
Spain	-0.001	0.011	-0.123	-0.041	0.020	-2.070	-32.25	2.31	-13.94	-24.23	2.35	-10.29	-0.014	0.017	-0.822
France	-0.028	0.011	-2.513	-0.072	0.021	-3.397	-32.24	2.31	-13.96	-24.22	2.35	-10.29	-0.012	0.018	-0.678
Ireland	-0.014	0.013	-1.069	-0.123	0.047	-2.629	-32.27	2.31	-13.98	-24.19	2.35	-10.27	0.026	0.041	0.640
Italy	-0.045	0.011	-4.088	-0.090	0.022	-4.193	-32.25	2.31	-13.97	-24.24	2.35	-10.31	-0.046	0.018	-2.544
Netherlands	0.030	0.012	2.529	-0.069	0.042	-1.625	-32.18	2.31	-13.96	-24.14	2.35	-10.27	0.038	0.036	1.057
Austria	0.030	0.011	2.693	-0.042	0.032	-1.323	-32.21	2.31	-13.94	-24.18	2.35	-10.27	0.028	0.027	1.029
Portugal	0.093	0.013	7.028	0.018	0.033	0.542	-32.19	2.31	-13.92	-24.14	2.36	-10.25	0.088	0.028	3.117
Finland	-0.012	0.011	-1.019	-0.071	0.027	-2.634	-32.25	2.31	-13.96	-24.22	2.35	-10.29	-0.018	0.023	-0.809
Sweden	0.025	0.011	2.189	-0.038	0.028	-1.349	-32.21	2.31	-13.94	-24.20	2.35	-10.29	-0.004	0.023	-0.174
UK	-0.030	0.011	-2.612	-0.085	0.026	-3.345	-32.24	2.31	-13.96	-24.22	2.35	-10.30	-0.027	0.022	-1.266
US	0.019	0.013	1.516	-0.003	0.015	-0.214	-32.23	2.31	-13.93	-24.21	2.36	-10.28	0.011	0.013	0.855
Japan	-0.026	0.011	-2.242	-0.051	0.015	-3.307	-32.27	2.31	-13.95	-24.23	2.36	-10.28	0.010	0.014	0.709

Note: S.E. is Standard Error

Table 3.7 - VARIATION OF COUNTRY DUMMIES ASSOCIATED WITH TWO-WAY PANEL DATA SPECIFICATIONS

	M4.1 associate			M4.2 associate			M4.3 associate		
	Coefficient	S.E.	t-ratio	Coefficient	S.E.	t-ratio	Coefficient	S.E.	t-ratio
Belgium	0.002	0.011	0.207	0.030	0.036	0.835	0.023	0.030	0.777
Denmark	-0.014	0.011	-1.251	-0.011	0.012	-0.913	-0.022	0.010	-2.228
Greece	0.025	0.013	1.912	0.019	0.015	1.296	0.019	0.012	1.573
Spain	-0.015	0.011	-1.380	-0.026	0.017	-1.500	-0.031	0.014	-2.130
France	-0.011	0.011	-0.995	-0.019	0.015	-1.284	-0.015	0.012	-1.185
Ireland	-0.040	0.012	-3.212	-0.019	0.028	-0.689	0.008	0.024	0.338
Italy	-0.023	0.011	-2.083	-0.031	0.014	-2.118	-0.039	0.012	-3.241
Netherlands	0.046	0.011	4.111	0.063	0.023	2.691	0.059	0.019	3.038
Austria	0.017	0.011	1.596	0.021	0.012	1.802	0.020	0.010	2.124
Portugal	0.048	0.013	3.681	0.052	0.014	3.771	0.059	0.011	5.175
Finland	-0.018	0.011	-1.713	-0.020	0.011	-1.868	-0.025	0.009	-2.760
Sweden	0.018	0.011	1.661	0.017	0.011	1.614	-0.002	0.009	-0.189
UK	-0.012	0.011	-1.117	-0.015	0.012	-1.335	-0.020	0.010	-2.138
US	0.010	0.012	0.827	-0.010	0.027	-0.355	-0.010	0.022	-0.464
Japan	-0.033	0.011	-2.983	-0.050	0.024	-2.073	-0.024	0.020	-1.200

Note: S.E. is Standard Error

Table 3.8 - VARIATION OF TIME DUMMIES ASSOCIATED WITH TWO-WAY PANEL DATA SPECIFICATIONS

	M4.1 associate			M4.2 associate			M4.3 associate		
	Coefficient	S.E.	t-ratio	Coefficient	S.E.	t-ratio	Coefficient	S.E.	t-ratio
1971	-0.166	0.018	-9.240	-0.173	0.020	-8.795	-0.114	0.019	-6.061
1972	-0.134	0.017	-7.675	-0.141	0.019	-7.255	-0.093	0.018	-5.244
1973	-0.099	0.017	-5.865	-0.104	0.018	-5.837	-0.066	0.016	-4.209
1974	-0.093	0.016	-5.809	-0.093	0.016	-5.834	-0.063	0.014	-4.499
1975	-0.099	0.015	-6.761	-0.101	0.015	-6.816	-0.078	0.013	-6.091
1976	-0.067	0.014	-4.827	-0.068	0.014	-4.933	-0.051	0.012	-4.336
1977	-0.052	0.013	-3.894	-0.054	0.013	-4.000	-0.043	0.011	-3.854
1978	-0.033	0.013	-2.560	-0.036	0.013	-2.698	-0.032	0.011	-2.926
1979	-0.012	0.013	-0.936	-0.011	0.013	-0.911	-0.013	0.010	-1.287
1980	0.000	0.012	0.030	0.002	0.013	0.180	-0.005	0.010	-0.467
1981	0.007	0.012	0.602	0.010	0.013	0.805	0.000	0.011	0.023
1982	0.023	0.013	1.736	0.025	0.013	1.899	0.013	0.011	1.153
1983	0.029	0.013	2.184	0.031	0.013	2.331	0.016	0.011	1.443
1984	0.048	0.014	3.518	0.052	0.014	3.614	0.034	0.012	2.852
1985	0.066	0.014	4.605	0.070	0.015	4.660	0.050	0.013	3.972
1986	0.079	0.015	5.212	0.079	0.015	5.282	0.058	0.013	4.531
1987	0.093	0.015	6.163	0.094	0.015	6.250	0.069	0.013	5.306
1988	0.120	0.016	7.662	0.122	0.016	7.769	0.092	0.014	6.748
1989	0.140	0.017	8.251	0.143	0.017	8.284	0.109	0.015	7.199
1990	0.151	0.018	8.260	0.154	0.018	8.338	0.115	0.016	7.061

Note: S.E. is Standard Error

3.6. Conclusion

After a brief discussion of growth accounting, this chapter investigates the role of TFP in two-stage. The first stage is a growth accounting exercise, which shows that TFP in general explains a large part of economic growth. Among the selected countries, we find that the USA achieves the least progress in TFP. This result might be well explained by the general technological leadership of the USA, which mainly depends on genuine research and innovation. By contrast, Japanese progress in TFP is the fastest. This might reflect the significant role of technological imitation and transfusion in the earlier period of Japanese growth.

The second-stage analysis contains a number of statistical regressions of ln (TFP). Coe and Helpman (1995) have suggested that the domestic and foreign R&D capital stocks are significantly and positively associated with TFP, but we find that such relationships are not consistent. Firstly, the relationships are sensitive to two key variables: the time trend, representing exogenous technological progress, and the capital stock. Secondly, they are sensitive to adding a lagged dependent variable and lagged domestic and foreign R&D capital stocks. Thirdly, they cannot survive after we control time difference by using two-factor panel data method.

The second-stage analysis also examines the role of foreign R&D spillover following Coe and Helpman (1995). Using alternative fixed panel data method, we find that the benefit of the foreign R&D capital stock is trade related. We also find that the time trend, reflecting exogenous technological progress, is a key element in explaining TFP progress. In addition, a positive externality due to the accumulation of physical capital is also revealed.

CHAPTER 4

THE CONDITIONAL CONVERGENCE MECHANISMS OF ECONOMIC GROWTH

SUMMARY: After examining the conditional growth convergence of GDP, this paper proposes and investigates two additional conditional convergence mechanisms. One is the conditional growth convergence of the capital stock, and the second is that of total factor productivity (TFP). Using panel data from 16 selected OECD countries, we show that all three conditional convergence mechanisms are statistically significant but differently determined. Our results provide little support for the standard view that GDP and capital stock convergences are equivalent. But this investigation of the conditional convergence of TFP reveals the empirical roles of technological diffusion, knowledge spill over and learning by doing, which are specifically discussed by endogenous growth theories.

KEY WORDS: Conditional Convergence, Economic Growth, Panel Data.

4.1. Introduction

Theoretical explanations for the convergence of economic growth across countries were first provided by Solow (1956) and Swan (1956) and recently updated by Barro and Sala-i-Martin (1992) and Mankiw, Romer and Weil (1992). There has been being a strong growth in empirical studies of the phenomenon. The studies by Baumol (1986) and particularly by Barro and Sala-i-Martin (1991; 1992), Mankiw, Romer and Weil (1992), Barro and Lee (1994), Barro and Sala-i-Martin (1995), Islam (1995), Caselli, Esquivel, and Lefort (1996), Barro (1997), Temple (1998), and Barro and Sala-i-Martin (2003) have been especially influential. It is widely accepted that there is strong evidence for conditional growth convergence, but the claims for absolute convergence are debated (De Long, 1988; Romer, 2001) due to a lack of global evidence (Barro and Sala-i-Martin, 1995; 2003).

The neo-classical theoretical foundation of growth convergence rests on the assumption of diminishing returns to capital (Barro and Sala-i-Martin 1991; 1992; Mankiw, Romer and Weil 1992; Barro and Sala-i-Martin 1995; Barro 1997; Lucas 2002; Barro and Sala-i-Martin 2003). Barro and Sala-i-Martin (1995; 2003) demonstrate that growth convergence is equivalent to capital convergence, under which each economy is expected to converge to its own steady state that in turn is determined by a number of explanatory variables. Mankiv, Romer, and Weil (1992), Barro and Sala-i-Martin (1992; 1995; 2003) employ a simple Cobb-Douglas model to show that the convergence speed of GDP in an economy around its steady state is theoretically determined by the shares and growth rates of factor inputs.

Provided that most economies work around their steady states (Caselli et al., 1996; Barro and Sala-i-Martin, 2003), the convergence speed is expected to be faster the further they are from their steady states, which in general is likely due to catch up mechanisms. Using a neoclassical model, Barro and Sala-i-Martin (1992; 1995; 2003) show that the USA, around its steady state, could achieve an average convergence speed of about 5%. This implies that the real convergence speed is likely to be higher because any further departure from steady state would potentially result in a high convergence speed. Moreover, given the leading position of the USA, economically and technically, other economies have the potential to achieve even higher convergence speeds, due to catch-up and knowledge diffusion.

Continuing interest in empirical studies of growth convergence is unsurprising. Growth has always been a central topic in economics and remains a central concern of modern macroeconomics. Data on growth is high profile and relatively reliable. The existing literature contains significant and consistent evidence for conditional growth convergence, which supports the neoclassical growth theory and provides a benchmark for further studies.

However, if the hypothesis of diminishing returns to capital were the fundamental mechanism determining growth convergence, we would have expected it, where possible, to have been subjected to cautious and detailed testing.

Unfortunately, at the macro level, there are few empirical tests of this hypothesis although Lucas (1990; 2002) discusses four hypotheses that might explain cross-country capital flows. Theoretically diminishing returns to capital imply capital convergence.

Strictly speaking, it is risky to assert that growth convergence is equivalent to capital convergence, and thus determined by diminishing returns to capital. Other convergence mechanisms are possible. In particular, there has been increasing emphasis on the role of general technological progress, represented by total factor productivity (TFP), on cross-country growth differences. Also known as the Solow residual, TFP is interpreted either as the growth contribution of all factors except capital and labour, or as reflecting the ignorance of neoclassical growth theory (Easterly and Levine, 2001; Hulten, 2000). Either way TFP should contain rich unexplored information. On the other hand, endogenous growth theories imply that several mechanisms such as technological innovation, technology transfer, knowledge spill over, investment in education and R&D, determine the progress of TFP. Thus, TFP is likely to play a crucial role in integrating recent endogenous theories into empirical studies.

TFP reflects the general technological and efficiency levels of an economy. It may reflect not only the differences in technologies but also more sophisticated institutional and management differences, such as the capacity for innovation and adoption of new technology, and management capacities. Thus TFP is a composite variable denoting the efficiency and effectiveness of an economy. A similar level of TFP is very likely to determine a similar level of output. Therefore, growth convergence is likely to be accompanied by TFP convergence with possible causality running from the latter to the former.

TFP, as it reflects a general level of technology, shares the properties of knowledge and technology, like diffusion, imitation, and spill over. It is clear these properties contribute to the convergence of TFP. For instance, technological spill over is driven by learning-by-doing; technological diffusion is driven by imitation; and there are also externalities of technology resulting from the absence of diminishing returns to innovation. Unfortunately, few studies address this kind of convergence mechanism. Yet studying TFP convergence provides a way to explore the determinants of technological imitation, diffusion, and spill over across countries.

This study has two objectives. Starting with an empirical analysis of conditional GDP growth convergence, we then investigate the underlying conditional capital convergence mechanism, i.e. the law of diminishing returns to capital. Further, we explore and examine the conditional convergence mechanism of TFP. These two convergence mechanisms are likely to help us understand the mechanism of conventional conditional growth convergence. More specifically, we examine respectively the links between the change rate of the capital stock and the level of the capital stock, and that between the change rate of TFP and a proxy of the TFP level, conditioned on some commonly-used variables.

The organisation of the rest of the chapter is as follows. Sections 2 and 3 present respectively the methodological framework and econometric specification.

The data are described in section 4, and the empirical results are presented and discussed in section 5. The key results are summarised in section 6.

4.2. The Empirical Framework

Key empirical studies on conditional growth convergence are Barro and Sala-i-Martin (1991; 1992), Mankiw, Romer and Weil (1992), Barro and Lee (1994), Barro and Sala-i-Martin (1995), Islam (1995), Caselli, Esquivel, and Lefort (1996), Barro (1997), and Barro and Sala-i-Martin (2003). The basic framework is a regression of per capita GDP growth rates on an initial condition plus a number of other explanatory variables. The initial condition, which is measured by the logarithm of per capita GDP, is intended to capture the development level of the economy. The logarithmic transform allows the coefficient on the initial condition to be interpreted as convergence speed. Overwhelming evidence suggests a negative association between growth and the initial condition (ibid). This implies that potentially an economy can grow faster the further it is from its steady state.

The steady state of an economy is determined by other explanatory variables - an array of choice and environmental variables (Barro and Sala-i-Martin, 1992; Barro and Lee 1994; Barro and Sala-i-Martin, 1995; Caselli, Esquivel, and Lefort, 1996; Barro, 1997; Barro and Sala-i-Martin, 2003). In most studies, these include private preferences and choices such as saving rates, labour supply, and fertility rate; government policies and interventions like tax rates and structure, public spending, provision of education and research, market distortion, infrastructure, maintenance of law and property rights; institutional characteristics like the legal, political and religions institutions; and others such as weather, geographic location, openness, terms of trade, warfare and external shocks. Changes in these variables would normally alter the steady state. An economy tends to converge to such a steady state. However, any shift of the steady state changes the distance of an economy from its steady state, and consequently alters its convergence speed.

For instance, more effective government polices or institutional systems may result in higher economic efficiency and effectiveness, and a consequent increase in steady state output. An ineffective and inefficient economy has more scope to improve its efficiency and effectiveness because it could learn and mimic those policies from more efficient economies. An improvement in government policies or institutional systems will push the steady state to a higher level, as will an improvement in TFP.

More specifically, poor countries, whose TFP levels are normally lower and could be raised by imitation, learning-by-doing, and technological diffusion and spill over as well as innovation, normally have much more scope to improve their TFP than do richer ones, who rely more on innovation and invention. In contrast to innovation, the costs of imitation, learning-by-doing, technological diffusion and spill over are trivial. This implies that a poor country could potentially grow faster than a rich one.

The above mechanisms can be captured by the conventional conditional convergence specification with respect to per capita GDP. In the majority of studies, the initial condition is denoted by the logarithm of GDP per capita of the start of each five-year period (Barro and Sala-i-Martin, 1991; 1992; Mankiw, Romer and Weil, 1992; Barro and Lee, 1994; Barro and Sala-i-Martin, 1995; Islam 1995; Caselli, Esquivel, and Lefort 1996; Barro 1997; Temple 1998; and Barro and Sala-i-Martin 2003). In contrast we use annual data, and thus initial conditions are represented by the logarithm of one period lagged per capita GDP.

In this literature the variables determining the steady state are chosen from a large set of variables including investment, inflation rate, the government consumption ratio, the male and female secondary and higher schooling rates, the product of the schooling and the GDP variables, the logarithm of life expectancy, the logarithm of the fertility rate, a rule of law index, the change in the terms of trade, a democracy index, the square of the democracy index, and regional or religion dummies. However, investment is not included in Barro's regressors (1997), partly because of the argument that the reverse causality from GDP growth to investment is likely to be more determining (Blomstrom, Lipsey and Zejan, 1996; Barro, 1997). Barro (1997) instead examines the determinants of investment, represented by the investment ratio, and those of the inflation rate.

Our selection of explanatory variables, depending upon data availability, differs slightly from the studies by Barro and Sala-i-Martin (1991; 1992), Barro and Lee (1994), Barro and Sala-i-Martin (1995), Barro (1997), and Barro and Sala-i-Martin (2003). The explanatory variables in this study are inflation rate, investment ratio, government consumption ratio, openness, an interaction between openness and initial condition, life expectancy, fertility rate, and urbanisation. The education variables are excluded from our principal regressions due to data limitations.

But to investigate the possible effects of education variables, this study provides auxiliary regressions based on five-year period data following existing studies (Mankiw, Romer, and Weil 1992; Barro and Lee 1994; Islam 1995; Barro and Sala-i-Martin 1995; Caselli, Esquivel and Lefort 1996; Barro 1997; and Barro and Sala-i-Martin 2003). Auxiliary regressions allow alternative education variables to enter the regressions. They also allow comparisons of regressions based respectively on annual and period average data.

An examination of conventional conditional growth convergence with respect to the above variables is presented as a benchmark in this study. Several alternative specifications are suggested to provide comparisons and possible further insights. In our framework, we do not assume the exogeneity of explanatory variables, but conduct Hausman tests for exogeneity. In the case of the presence of endogeneity, we employ instrumentals to provide two-stage least squares (2SLS) estimates.

We then investigate the diminishing return to capital stock within the framework of conditional capital convergence. In such a specification, the annual change rate of per capita capital stock is regressed on an initial condition represented by one period lagged capital stock and a number of explanatory variables, excluding the investment ratio. The implication of the initial condition and other explanatory variables remains the same as those in the conventional conditional growth convergence literature.

We propose further similar framework to examine the third conditional convergence mechanism with respect to the change rates of TFP. But investigating capital and TFP convergence requires data on capital stock and TFP levels. We show in chapter 3 that the capital stock figures can be estimated from annual investment data, but the initial level of TFP cannot be directly estimated, and so this study uses a range of alternative proxies.

Two alternative variables, per capita capital stock and real GDP per capita are employed to approximate the level of TFP, which is assumed to be ordinal. It is reasonable to argue that a high level of GDP per capita or capital stock per capita likely reflects a high level of TFP. We later show that the correlation between per capita capital stock and GDP per capita is reasonably high, which provides some support for these two proxies. For a comparative and sensitivity analysis of these two variables, we present alternative regression results for the conditional convergence of capital stock, where per capita GDP replaces capital stock per capita as the initial condition.

To deal with possible bias due to economic scale, we suggest two additional alternatives to reflect the level of TFP. The two new variables are created by multiplying the logarithm of per capita GDP and per capita capital stock respectively by the corresponding logarithm of population. The four alternatives are intended to provide information about the sensitivity and robustness of the initial condition. It will be shown that using the different proxies for initial conditions does change the central message of this study.

4.3. Panel data analysis

Panel data methods are the preferred technology for pooled cross-country and time series analysis (Durlauf and Quah, 1999; Temple, 1999), since panel data provide more information, greater efficiency, and less multi-collinearity (Baltagi, 1999). Baltagi (1999; 2005) and Wooldridge (2001) summarise the core technologies and review various issues in econometric methodology. In this thesis, appendix A provides detailed account of panel data techniques and various test statistics. This chapter uses a two-factor panel data approach or a two-way error components regression model. A specified cross-country panel data framework has double indices on its variables such that:

$$r_{i,t} = \beta_0 + \beta_1 \cdot X_{i,t} + \beta_2 \cdot Z_{i,t} + u_{i,t} \qquad (1)$$

$$i = 1, 2, \dots, N \text{ and } t = 1, 2, \dots, T$$

where i denotes countries, t denotes periods, $r_{i,t}$ presents alternatively the change rate of per capita GDP, per capita capital stock and TFP, and $X_{i,t}$, $Z_{i,t}$ present respectively initial conditions and other explanatory variables. The general error term $u_{i,t}$ can be decomposed into a two-factor error components disturbance model:

$$u_{i,t} = d_i + d_t + v_{i,t} \qquad (2)$$

$$i = 1, 2, \dots, N \text{ and } t = 1, 2, \dots, T$$

where d_i indicates the unobservable individual country effect, d_t is the associated unobservable time effect, and $v_{i,t}$ is the remaining independent stochastic error term. Treating error components for d_i and d_t differently results respectively in fixed effects and random effects models.

In the fixed effects case, $v_{i,t}$ is the only independent stochastic error term and both d_i and d_t are assumed to be fixed parameters - that is dummies to be estimated in the model. This specification introduces many individual dummies and hence likely suffers from the loss of degrees of freedom. The parameters of interest can be estimated by least squares dummy variables (LSDV). However, a limitation of this approach is that the character of any either country-invariant or time-invariant variables such as ethnicity, religion, location, or membership of an economic group cannot be exploited.

The random effects model treats both d_i and d_t as well as $v_{i,t}$ as stochastically independent disturbances. The direct result is that the relative effects of the unobservable country and time effects as well as the error term can be estimated and compared. The clearest advantage of this approach is that one can exploit the possible affects from the country or time invariant characteristics by adding dummies. This model can be estimated by using Generalised Least Squares (GLS).

Although the random effects model appears to have some appealing properties, it is not statistically superior to the corresponding fixed effects model. In fact, the fixed effects model in panel data analysis has proved to be generally preferable (Hausman, 1978). In practice, a comparison can be made by Hausman's LM test statistic (Hausman, 1978). A large value of the Hausman statistic favours the fixed effects over the random effects model.

Various other test statistics are used for model selection between panel data approaches. First, the adjusted R squared is the simplest and most widely reported statistic. Second, the Likelihood Ratio (LR) and F statistics are used for model selection between OLS and LSDV – tests of the joint fixed-effect. Second, the Lagrange Multiplier (LM) test can be used to decide between OLS and Random Effects models – tests of the random-effect. Panel data technology is also generally more efficient than OLS and the most appropriate can be chosen by statistical diagnostic tests. Above all, a range of panel data approaches exists and can be used to reduce the risks caused by methodological problems. For more details see appendix A.

4.4. Data description

The principal data source used is World Development Indicators (World Bank, 2000). Some data unavailable from this source, i.e. unemployment rates and labour shares (adjusted wage shares in the total economy) are from the European Commission (2002). The sample includes all the EU states except Germany, plus the United States and Japan (hereafter 16 OECD countries). The choice criteria are availability and accessibility. The data series run from 1960 to 1997, and total observations are 592.

Per capita GDP growth rates are taken directly from the World Bank. Capital stock data were generated by a three-stage approach by using investment data, and change rates of TFP series were estimated by growth accounting that uses the data from European Commission (2002). For details, see chapter three and appendix B.

The explanatory variables comprise the initial conditions, inflation rate, the investment ratio, government consumption ratio, openness, life expectancy, fertility rate, and urbanisation ratio. Their descriptions are as follows: first, per capita GDP is measured in 1995 US dollars at PPP. Second, the inflation rate is measured using the consumer price index, while the investment rate and the government consumption ratio refer respectively to the percentages of gross domestic fixed investment and of general government consumption in GDP. Third, life expectancy and fertility rate refer to life expectancy at birth and the fertility rate per woman respectively. Finally, openness is measured separately by exports and imports of goods and services, and also by their joint sum expressed as a share of GDP. For more details, see appendix E.

Data on educational attainment are taken from Barro and Lee (2001). The figures were constructed at five-year intervals from 1960 to 1995, following previous studies (Barro and Lee 1993; 1996). The data are generated into two categories, educational attainment for the population aged, respectively 15 and over and aged 25 and over. For each category, four levels of schooling are estimated: no school, primary, secondary, and higher education. For each level of education, data on educational attainment is provided separately from educational completions. The data are generally constructed for the whole population as well as male and female populations. In addition, the average number of years of schooling achieved by the average person in each country is also estimated. For details, see appendix E.

The statistical descriptions of the data are presented in appendix F. The graphic descriptions of the data are presented in appendix G.

Table 4.1 summarises the pair-wise correlation coefficients between the three dependent variables and the four explanatory initial conditions. As can be seen, the correlation between any two dependent variables is positive and so are those between any two explanatory variables. But the correlations between any dependent variable and initial condition are negative. This supports the absolute convergence hypothesis, which is consistent with Baumol (1986), but criticised by De Long (1988).

TABLE 4.1 - CORRELATION MATRIX OF SELECTED VARIABLES

	r^{GDP}	r^{K}	r^{TFP}	$GDP(-1)$	$GDP^{a}(-1)$	$K(-1)$	$K^{a}(-1)$
r^{GDP}	1.000	0.550	0.895	-0.328	-0.195	-0.344	-0.213
r^{K}	0.550	1.000	0.364	-0.394	-0.223	-0.464	-0.272
r^{TFP}	0.895	0.364	1.000	-0.348	-0.200	-0.354	-0.212
$GDP(-1)$	-0.328	-0.394	-0.348	1.000	0.490	0.948	0.492
$GDP^{a}(-1)$	-0.195	-0.223	-0.200	0.490	1.000	0.444	0.986
$K(-1)$	-0.344	-0.464	-0.354	0.948	0.444	1.000	0.498
$K^{a}(-1)$	-0.213	-0.272	-0.212	0.492	0.986	0.498	1.000

r^{GDP}, r^{K}, r^{TFP} are respectively the change rate of per capita GDP, capital stock and TFP. GDP(-1) and K(-1) are respectively the logarithms of one period lagged per capita GDP and the capital stock. $GDP^{a}(-1)$ and K^{a} (-1) are respectively the logarithms of one period lagged per capita GDP and capital stock multiplied by the logarithm of population.

4.5. Findings and implication

This chapter does not provide a detailed statistical comparison of different panel data models, but focuses directly on the results from a two-way fixed panel data model[1].

4.5.1 Conditional growth convergence

As a benchmark, table 4.2 presents the regression results for the conditional convergence of growth. The specification follows the basic framework employed by Barro and Lee (1994), Barro and Sala-i-Martin (1995), Caselli et al. (1996), Barro (1997) and Barro and Sala-i-Martin (2003), but due to data availability, the selection of variables is slightly different. As expected by theories, table 4.2 shows that there is strong evidence for conditional growth convergence.

Under different specifications, the coefficient on the initial condition varies from 4.955 to 8.004, a level more than twice the 2.25 to 2.54 estimated by Barro and Sala-i-Martin (1991; 1992; 1995; 2003) and Barro (1997)[2]. It is however close to the estimates of 5.44 to 7.92, which Islam (1995) and Caselli et al. (1996) present, within a dynamic panel data specification. A high coefficient means a more rapid convergence, and this can be understood as economies are relatively close to their steady states (Caselli et al., 1996; Barro and Sala-i-Martin, 2003). The relatively high quality of OECD data increases our confidence in these results.

[1] Many studies suggest the empirical superiority of the two-way fixed panel data model. This study and earlier chapter 3 study on TFP support this view. Appendix M presents three samples of detailed results of regressions and tests of table 4.2.

[2] Barro's sample is smaller than ours, although it covers more than 90 countries over three, five-year periods.

TABLE 4.2 - ALTERNATIVE SPECIFICATIONS FOR THE GROWTH REGRESSION

Explanatory variables		Specification with r^{GDP} as dependent variable					
		M2.1	M2.2	M2.3	M2.4	M2.5	M2.6
Constant		152.52 (4.192)***	110.04 (3.001)***	190.00 (5.181)***	144.61 (3.892)***	161.01 (4.207)***	112.25 (2.702)***
Ln (GDP per capita)		-6.647 (5.883)***	-7.816 (6.957)***	-5.862 (5.044)***	-6.878 (5.977)***	-5.832 (4.927)***	-4.955 (3.860)***
Inflation rate		-0.196 ^{E} (7.796)***	-0.190 (7.705)***	-0.197 (7.640)***	-0.191 (7.503)***	-0.153 (5.949)***	-0.194 (5.114)***
Investment ratio		0.248 ^{E} (7.641)***	0.296 (9.213)***	0.225 (6.495)***	0.246 (7.548)***	--	0.054 (1.068)
Government consumption ratio		-0.227 ^{E} (3.913)***	-0.157 (2.688)***	-0.284 (4.817)***	-0.217 (3.695)***	-0.381 (6.644)***	-0.159 (2.225)***
Openness	Export/GDP	--	0.156 (7.725)***	--	--	--	--
	Import/GDP	--	--	0.089 (3.498)***	--	--	--
	Total trade/GDP	0.073 (6.106)***	--	--	0.001 (0.011)	0.079 (6.280)***	0.090 (6.746)***
(Total trade/GDP) * Log (GDP per capita)		--	--	--	0.007 (1.051)	--	--
Log (life expectancy)		-21.68 (2.263)**	-9.552 (0.988)	-31.56 (3.251)***	-19.10 (1.933)*	-24.56 (2.438)***	-15.19 (1.467)
Fertility		-0.816 (2.699)***	-0.658 (2.210)**	-1.099 (3.607)***	-0.891 (2.868)***	-0.575 (1.817)*	-0.294 (0.859)
Urbanisation		0.055 (2.061)**	0.037 (1.416)	0.073 (2.681)**	0.048 (1.745)*	.0.100 (3.660)***	0.055 (1.772)*
Estimated error Auto-correlation		0.1494	0.1238	0.1574	0.1452	0.1669	0.1308
R^2		0.6385	0.6522	0.6219	0.6392	0.5988	0.5592
Adjusted R^2		0.5984	0.6129	0.5791	0.5985	0.5552	0.5098
Akaike information criterion		4.064	4.026	4.109	4.079	4.165	4.229
Schwarz Bayesian information criterion		4.508	4.470	4.553	4.509	4.601	4.676
Ramsey reset test of function form (LR)		0.164 0.684)	0.330 (0.566)	0.345 (0.557)	0.102 (0.749)	2.134 (0.144)	0.538 (0.463)
Hausman test of endogeniety (LM)		85.43 (0.000)	--	--	--	--	--

Dependent variable is percentage annual growth rate. The regression method is two-way LSDV; t-statistics in parentheses with * significant at 10%, ** at 5% and *** at 1%. Superscript ^{E} denotes presence of endogeneity detected by Hausman-type Lagrange multiplier test statistic with p-value in parenthesis. Ramsey reset is likelihood ratio test statistic with p-values in parentheses. M2.6 is estimated by 2SLS with one-period lagged explanatory variables as instrumental variables. Appendix M presents the detailed results of regressions and related tests of M2.1 and M2.6. A dynamic panel data estimation of M2.1 with GMM is also presented in appendix M for comparison.

The negative coefficients on inflation rate, in table 4.2, are significant and robust across alternative regressions. This is consistent with existing evidence that supports the consensus that inflation is costly and hence bad for growth (Briault 1995; Barro 1997; Barro and Sala-i-Martin 2003). Specification M2.1 identifies the endogeneity of inflation and the subsequent 2SLS regression M2.6 confirms that inflation's effect is negative and significant.

Table 4.2 demonstrates a strong link between investment and growth, which supports the consensus that an increase in the savings rate raises steady state output and thus boost growth. This is consistent with some studies (Delong and Summers, 1991; Mankiw, Romer and Weil, 1992; Levine and Renelt, 1992; Sala-i-Martin, 1997), though the direction of causality is disputed (Blomstrom, Lipsey and Zejan, 1996; Barro, 1997). Barro (1997) drops investment from his specification due to concerns of causality. Barro and Sala-i-Martin (2003) confirm the positive causality from investment to growth. Specification M2.1 identifies the endogeneity of investment and subsequent 2SLS regression M2.6 shows that investment is positive though insignificant. However, a comparison of M2.5 to M2.1 shows that the presence of the investment variable leads to a slight improvement in the degree of fit, but does not affect the model's central message.

The negative coefficients on general government consumption in table 4.2, are also significant and robust across alternative regressions. This is consistent with the work of Barro and Lee (1994), Barro and Sala-i-Martin 1995, Barro 1997, and Barro and Sala-i-Martin 2003). It suggests that the cost of general government consumption exceeds the benefit, in particular when general government consumption is generally very large in the selected OECD countries. Specification M2.1 also identifies the endogeneity of general government consumption, but the subsequent 2SLS regression M2.6 confirms that the impact of general government consumption is still negative and significant.

The effects of alternative proxy measures of openness are investigated in some detail, though table 4.2 presents supportive evidence that openness is generally good for growth. In specifications M2.1, M2.2 and M2.3, three alternative variables – the ratios of total trade, imports and exports in GDP are used. Exports are expected to be the most significant variables, because they link directly to aggregate demand and output. This is confirmed by, first, the fact that the t-value for exports is the largest, and second, when openness is represented by exports, the adjusted R squared tends to increase while the Akaike and the Schwarz Bayesian information criteria decrease. In addition, introducing an interactive variable between openness and ln(GDP per capita) results in the insignificance of openness, though the interactive variable is also insignificant. This appears a symptom of multi-colinearity between openness and the interactive term. As a result, the interactive term was dropped.

The negative coefficient on life expectancy differs from Barro and Sala-i-Martin (1995), Barro (1997) and Barro and Sala-i-Martin (2003). They interpret their positive sign on life expectancy as reflecting the contribution of human capital. However, Caselli et. al. (1996), using the same data, report insignificant or even negative coefficients. The argument that higher life expectancy raises output per capita for human capital reasons, is possibly plausible for countries with relatively low life expectancies, as might be true for some of Barro's sample of 100 countries. In contrast, it is unlikely in countries where life expectancy is well in excess of retirement age, where *cet. par.* higher life expectancy is instead likely associated with lower output per capita. More likely, higher life expectancy creates an extra burden on the economy.

The coefficients on the fertility variable are negative and robust, which is consistent with the standard explanation that focuses on the opportunity costs of child rearing-cost (Barro 1997; Barro and Sala-i-Martin, 2003). The coefficients on urbanisation are positive, though not consistently significant across specifications. they tend to indicate a positive relation to growth, perhaps reflecting size, proximity or quality of infrastructure effects.

With respect to specification M2.1, three variables: the inflation rate, investment ratio, and government general consumption, are diagnosed as endogenous by Hausman's LM test, with one period lagged explanatory variables as instruments. Therefore M2.6 is estimated by 2SLS using the same instrumental variables to provide consistent estimates, in which the investment ratio, fertility, and life expectancy are insignificant. But the central characteristics, in particular the conditional growth convergence, are preserved.

Clearly, the main results from the above conditional growth regression on 16 OECD countries portray a benchmark story that is consistent with the literature. The unexpected results on the life expectancy variable reflect the sample of countries, and the sign on the urbanisation variable is expected. The strength of the results indirectly reflects the quality of the data set.

To address the role of education variables, Table 4.3 presents results of auxiliary regressions based on five-year period data, in which four alternative education variables enter M3.2, M3.3, M3.4 and M3.5. The coefficients on all the education variables are negative, though insignificant. The negative coefficients seem to be consistent with the results reported by Islam (1995) and Caselli et al. (1996) where the MRW model is used. As noted in chapter 2 there are few obvious explanations for the negative coefficients on the education variables, as education is expected to be positively linked to economic growth.

Fortunately, a comparison among alternative specifications in table 4.3 shows little impact from the insignificant educational variables. As can be seen, the estimates of the coefficients of M3.1 are rather consistent with those correspondences of M3.2, M3.3, M3.4 and M3.5, though some small differences are noticeable. In general, the results across different specifications are robust regardless of educational variables. Further, given the insignificance of alternative educational variables for the sample we studied, the potential risk of misspecification bias due to ignore education variables is statistically insignificant.

Table 4.3 also provides an empirical comparison between utilisations of annual and period data, though there are few differences worth remarking. This can be seen by the estimated coefficients and t-values in specifications M3.1 and M3.6. Clearly, both the coefficients and t-values of M3.6 are slightly larger than the corresponding coefficients of M3.1. This is likely to be a consequence of the larger sample employed by M3.6. By contrast, the smaller adjusted R^2 of M3.6 results from the utilisation of more dummies.

TABLE 4.3 - ALTERNATIVE SPECIFICATIONS FOR AUXILIARY REGRESSION

Explanatory variables	Specification with r^{GDP} as dependent variable					
	M3.1	**M3.2**	**M3.3**	**M3.4**	**M3.5**	**M3.6**
Type of Sample (observations)	Period average (120)					Annual (592)
Constant	135.26 (3.297)***	126.42 (3.038)***	132.88 (3.208)***	132.05 (3.192)***	131.98 (3.153)***	152.52 (4.192)***
Log (GDP per capita)	-4.998 (3.853)***	-5.203 (4.029)***	-5.190 (3.846)***	-5.153 (3.911)***	-5.149 (3.826)***	-6.647 (5.883)***
Log (Secondary education attained aged 15 and over)	--	-0.600 (1.631)	--	--	--	--
Log (Secondary education completed aged 15 and over)	--	--	-0.111 (0.542)	--	--	--
Log (Higher education attained aged 15 and over)	--	--	--	-0.159 (0.731)	--	--
Log (Average schooling aged 15 and over)	--	--	--	--	-0.684 (0.447)	--
Inflation rate	-0.124 (3.180)***	0.108 (2.702)***	0.120 (2.998)***	0.120 (3.053)***	0.117 (2.791)***	-0.196 (7.796)***
Investment ratio	0.116 (2.181)**	0.103 (0.931)*	0.113 (2.095)**	0.113 (2.111)**	0.111 (2.038)**	0.248 (7.641)***
Government consumption ratio	-0.183 (2.529)**	-0.183 (2.546)**	-0.181 (2.484)**	-0.192 (2.605)**	-0.190 (2.557)**	-0.227 (3.913)***
Openness (Total trade/GDP)	0.0690 (4.295)***	0.0669 (4.176)***	0.0683 (4.194)***	0.0682 (4.205)***	0.0687 (4.230)***	0.073 (6.106)***
Log (life expectancy)	-20.62 (1.894)*	-17.90 (1.639)	-19.70 (1.781)*	-19.44 (1.761)*	-19.35 (1.713)*	-21.68 (2.263)**
Fertility	-0.733 (1.894)*	-1.011 (2.409)**	-0.775 (1.957)**	-0.795 (2.002)**	-0.809 (1.907)*	-0.816 (2.699)***
Urbanisation	0.0422 (1.185)	0.0714 (1.803)*	0.0520 (1.298)	0.0441 (1.232)	0.0560 (1.185)	0.055 (2.061)**
Adjusted R^2	0.7737	0.7778	0.7719	0.7725	0.7717	0.5984

Dependent variable is percentage growth rate. Panel II.A is estimated by OLS and others are estimated by two-way LSDV; t-statistics in parentheses with * significant at 10%, ** at 5% and *** at 1%.

4.5.2 Conditional capital convergence.

A framework similar to that for conditional growth convergence is used in table 4.4, to explore conditional capital stock convergence. With the rate of growth of capital stock per capita in one year lagged term as the dependent variable, a significant negative coefficient on the logarithm of capital stock per capita - the initial condition – indicates a capital stock convergence. However, two statistics indicate some problems of model misspecification. The Ramsey reset test statistic does not reject misspecification likely due to omitted variables, and the higher error autocorrelation coefficient suggests the need for a lagged specification.

Therefore, three additional variables are proposed. The interest rate spread[3] and lagged GDP per capita growth are introduced to capture cost and demand conditions for capital investment (Romer, 2001: 381-385). The lagged dependent variable is further added to deal with autocorrelation. M4.2 and M4.3 show that the introduction of new variables helps to reduce both the misspecification problem and auto-correlation.

Two of the newly introduced variables, lagged GDP and capital growth, as expected, are positively related to the dependent variable, but the magnitude of the coefficient for capital stock growth is much bigger than that for GDP growth. This suggests that capital growth is more dependent on its own immediate past, than on

[3] Interest rate spread is the interest rate charged by banks on loans to prime customers minus the interest rate paid by commercial or similar banks for demand, time, or savings deposits.

TABLE 4.4 - ALTERNATIVE SPECIFICATIONS FOR CAPITAL STOCK REGRESSION I

Explanatory variables	Specification with r^K as dependent variable			
	M4.1	M4.2	M4.3	M4.4
Constant	48.96 (2.151)**	5.183 (0.310)	18.90 (4.521)***	-7.365 (0.431)
Log of capital stock Per capita	-1.765 (5.707)***	-1.070 (4.389)***	-1.977 (4.515)***	-1.035 (4.174)***
Capital stock growth Lagged one period	--	0.653 (20.94)***	0.636 (15.07)***	0.656 (20.88)***
GDP growth Lagged one period	--	0.049 (2.677)***	0.068 (2.969)***	0.068 (2.969)***
Interest rate spread	--	--	-0.024 (0.792)	--
Inflation rate	-0.043 (2.720)***	-0.036^E (3.312)***	-0.014 (1.107)	-0.051 (3.462)***
Government Consumption ratio	-0.180 (5.206)***	-0.084^E (3.375)***	-0.079 (2.069)**	-0.044 (1.641)
Openness (Total trade/GDP)	0.006 (0.801)	0.005 (0.921)	--	0.007 (1.226)
Log (life expectancy)	-6.399 (1.148)	1.526 (0.374)	--	4.318 (1.038)
Fertility	0.404 (2.115)**	0.077 (0.568)	--	0.126 (0.917)
Urbanisation	0.030 (1.863)*	0.022 (1.950)*	0.062 (2.571)**	0.014 (1.180)
Estimated error auto-correlation	0.7067	0.0409	0.0318	0.0323
R^2	0.7173	0.8699	0.9247	0.8680
Adjusted R^2	0.6866	0.8551	0.9088	0.8529
F test	23.32	58.50	58.24	57.52
Akaike information criterion	3.153	2.389	2.088	2.403
Ramsey reset test of function form (LR)	71.25 (0.000)	2.251 (0.134)	0.143 (0.705)	0.592 (0.441)
Hausman test of endogeniety (LM)	--	24.90 (0.000)	--	--
Observations	592	592	338	592

Dependent variable is capital stock percentage annual growth rate. t-statistics in parentheses with * significant at 10%, ** at 5% and *** at 1%. Superscript ^{E} denotes presence of endogeneity detected by Hausman-type Lagrange multiplier test with p-value in parenthesis. Ramsey reset is likelihood ratio test statistic with p-values in parentheses. M4.4 is estimated by 2SLS with one-period lagged explanatory variables as instrumental variables.

previous GDP growth. In contrast, the interest rate spread is not significant, but due to data availability, its inclusion results in a substantial reduction in sample size. Therefore our focus is on specification M4.2, which excludes it.

In contrast to the results of tables 4.2 and 4.3, table 4.4 presents a different picture. As can be seen in M4.2, first the significant negative coefficient on the log of capital stock per capita initial condition confirms the capital stock convergence result. However, the convergence coefficient is well below 2.00, which suggests a slow convergence process.

Second, significant negative coefficients on inflation and general government consumption along with a significant positive coefficient on urbanisation are consistent with those of tables 4.2 and 4.3. The same interpretations are applied. Especially, higher urbanisation, which in part reflects the scale of the economy, the quality of infrastructure, better provision of public services, and thus lower external costs, is expected to encourage investment.

Third, the openness variable is insignificant. It is understandable that the capital flows between these OECD countries were little influenced by their degree of openness during the sample period. This result is consistent with Lucas's study of cross-country capital flows (Lucas, 2002).

In addition, fertility and life expectancy have no significant relationship with capital stock growth. It is indeed hard to find a theory or explanation that could establish a plausible linkage between capital growth and either fertility or life expectation.

Based on M4.2, endogeneity is diagnosed as associateed with two variables: the inflation rate and general government consumption. This results from Hausman's test, using lagged variables as instrumentals. Hence M4.4 presents an alternative estimate with 2SLS, using the same instrumentals. The main results of M4.2 are preserved, though the general government consumption and urbanisation variables become insignificant.

For comparison, we employ per capita GDP to replace per capita capital stock as the initial condition. As can be seen in table 4.5, the initial model specification M5.1 suffers from exactly the same problem as M4.1, and can be improved in the same way. The estimated results in table 4.5 are highly consistent with those in table 4.4. When studying capital stock convergence, per capita GDP can be used to approximate per capita capital stock as an initial condition.

This analysis shows the existence of conditional capital stock convergence. But it also demonstrates that the characteristics of the conditional convergences of capital stock are different from those of GDP. We find little evidence to support the theory that conditional GDP growth convergence is equivalent to conditional capital stock growth convergence.

TABLE 4.5 - ALTERNATIVE SPECIFICATIONS FOR CAPITAL STOCK REGRESSION II

Explanatory variables	Specification with r^K as dependent variable			
	M5.1	M5.2	M5.3	M5.4
Constant	99.26 (4.192)***	-6.301 (0.366)	24.31 (3.700)***	-6.132 (0.348)
Log of GDP per capita	1.532 (2.092)**	-1.578 (3.027)***	-2.644 (3.608)***	-1.482 (2.811)***
Capital stock growth one period lagged	--	0.695 (21.99)***	0.721 (17.47)***	0.696 (21.80)***
GDP growth one period lagged	--	0.054 (2.934)***	0.072 (3.100)***	0.059 (3.166)***
Interest rate spread	--	--	-0.012 (0.400)	--
Inflation rate	-0.058 (3.625)***	-0.041^E (3.814)***	-0.032 (2.601)***	-0.056 (3.830)***
Government Consumption ratio	-0.190 (5.351)***	-0.094^E (3.731)***	-0.125 (2.921)***	-0.053 (1.924)*
Openness (Total trade/GDP)	0.006 (0.796)	0.006 (1.157)	--	0.008 (1.449)
Log (Life expectancy)	-25.47 (4.089)***	2.150 (0.479)	--	4.788 (1.049)
Fertility	0.326 (1.665)*	0.046 (0.341)	--	0.097 (0.701)
Urbanisation	0.012 (0.724)	0.025 (2.080)**	0.061 (2.357)**	0.015 (1.284)
Estimated error auto-correlation	0.7297	0.0353	0.0474	0.0261
R^2	0.7025	0.8675	0.9226	0.8649
R^2 adjusted	0.6701	0.8523	0.9063	0.8494
F specification test	21.70	57.23	56.59	55.97
Akaike information Criterion	3.204	2.408	2.114	2.427
Ramsey Reset test on function form (LR)	97.21 (0.000)	3.814 (0.051)	0.943 (0.331)	1.392 (0.238)
Hausman test on Endogeniety (LM)	--	25.60 (0.000)	--	--
Observations	592	592	338	592

Dependent variable is capital stock percentage annual growth rate. t-statistics in parentheses with * significant at 10%, ** at 5% and *** at 1%. Superscript ^{E} denotes presence of endogeneity detected by Hausman-type Lagrange multiplier test statistic with p-value in parentheses. Ramsey Reset is likelihood ratio test statistic with p-value in parentheses. M5.4 is estimated by 2SLS estimation with one-period lagged explanatory variables as instrumental variables.

4.5.3 Conditional TFP convergence.

TFP, reflecting the level of technology and efficiency in the widest sense, is believed to be the key factor driving economic growth. We have examined the role of TFP progress in the growth accounting exercise and some possible associations with the level of TFP in the last chapter. A framework similar to that for conditional growth convergence is used here to explore the possible determinants and characteristics of TFP growth. Table 4.6 presents the regression results for alternative initial conditions, when the other explanatory variables remain the same as for conditional growth convergence. The significant negative coefficients on the initial condition are consistently observed, no matter which measure is employed. This suggests that the conditional convergence of TFP is both significant and robust.

The logarithm of per capita GDP and its correspondence[4] appear better to represent the initial condition, and this can be seen in several statistics in table 4.6. In contrast to two alternative initial conditions, first they help the model specification pass the Ramsey reset test. Second, they produce higher t statistics. Third, all model selection criteria favour them. Clearly, alternative proxies for the initial condition produce few differences in other variables except for life expectancy.

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[4] See table 4.6, footnote 1

TABLE 4.6 - ALTERNATIVE SPECIFICATIONS FOR THE CHANGE RATE OF TFP REGRESSION

Explanatory variables	Specification with r^{TFP} as dependent variable				
	M6.1	M6.2	M6.3	M6.4	M6.5
Constant	118.98 (3.306)***	102.82 (2.857)***	162.27 (4.424)***	154.25 (4.196)***	85.28 (2.255)**
Log of GDP per capita	-8.308 (7.435)***	--	--	--	-6.615 (5.621)***
GDP per capita correspondence①	--	-0.500 (8.165)***	--	--	--
Log of capital stock per capita	--	--	-2.065 (4.142)***	--	--
Capital stock per capita correspondence②	--	--	--	-0.131 (4.601)***	--
Inflation rate	-0.141 (5.687)***	-0.147 (5.993)***	-0.128 (4.923)***	-0.131 (5.076)***	-0.116 (4.542)***
Investment ratio	0.098^{E} (3.059)***	0.080 (2.534)**	0.079 (2.398)**	0.075 (2.288)**	-0.059 (1.305)
Government consumption ratio	-0.184^{E} (3.196)***	-0.254 (4.394)***	-0.144 (2.425)**	-0.164 (2.775)***	-0.112 (1.726)*
Openness (Total trade/GDP)	0.060 (5.084)***	0.039 (3.282)***	0.055 (4.498)***	0.049 (3.955)***	0.073 (5.905)***
Log (life expectancy)	-10.76 (1.135)	-6.162 (0.651)	-33.94 (3.778)***	-31.58 (3.500)***	-6.523 (0.665)
Fertility	-0.027 (0.092)	-0.176 (0.593)	0.004 (0.013)	-0.027 (0.087)	0.412 (1.322)
Urbanisation	0.102 (3.879)***	0.088 (3.421)***	0.074 (2.778)***	0.072 (2.676)***	0.101 (3.595)***
Estimated error Auto-correlation	0.042	0.027	0.035	0.031	0.048
R^2	0.5326	0.5415	0.5002	0.4038	0.4932
R^2 adjusted	0.4799	0.4907	0.4448	0.4488	0.4363
Akaike information criterion	4.042	4.023	4.109	4.102	4.056
Schwarz Bayesian information criterion	4.486	4.467	4.553	4.546	4.502
Ramsey reset test of function form (LR)	0.042 (0.837)	0.033 (0.856)	2.928 (0.087)*	3.076 (0.079)*	0.462 (0.497)
Hausman test of endogeniety (LM)	83.02 (0.000)	--	--	--	--

① GDP per capita correspondence is the product of log GDP per capita and log population. ② Capital stock per capita correspondence is the product of log capital stock per capita and log population. Dependent variable is percentage annual growth rate. t-statistics in parentheses with * significant at 10%, ** at 5% and *** at 1%. Superscript ^{E} denotes presence of endogeneity detected by Hausman-type Lagrange multiplier test statistic with p-value in parentheses. Ramsey reset is likelihood ratio test statistic with p-values in parentheses. M6.5 is estimated by 2SLS with one-period lagged explanatory variables as instrumental variables.

The main results in table 4.6 are similar to those in conventional conditional GDP convergence studies. The inflation rate and government consumption ratio appear to be strongly and negatively linked to the change rate of TFP. The same mechanisms and interpretations are likely to apply. For example, higher inflation reduces macro stability and hence increases economic risk, which channels resources away from improving TFP. Government consumption crowds out both private consumption and the investment that might improve TFP.

The investment ratio, openness and urbanisation are positively linked to TFP. The positive coefficient on the investment ratio suggests that capital accumulation, which has a positive association with GDP growth, has a similar link with TFP. It is understandable that capital accumulation can provide various channels to improve TFP. New investment is commonly associated with technological diffusion, spill over and learning by doing. Meanwhile, the positive coefficient on openness suggests that the relative scale of trade increases the possibility of technological diffusion. In addition the urbanisation result may signal that the higher the level of infrastructure, the greater the capacity to absorb new ideas.

Life expectancy is consistently and negatively associated with the dependent variable. But its significance is sensitive to the choice of initial conditions. Recall the argument that increased life expectancy in developed economies is an economic burden and likely pre-empts resources that could have been used to improve TFP, then the negative sign is expected.

However, table 4.6 shows no clear association between fertility and TFP. This is unsurprising for it is difficult to imagine a clear link between fertility and TFP in developed countries. In contrast, for the developing countries that form the bulk of Barro's (1997) sample, it is possible to envision a situation where a higher fertility rate with a low infant mortality rate could signal both an immediate economic burden as well as a longer run increase in labour supply, with consequent disincentive to TFP progress.

Hausman's test with lagged explanatory variables as instrumental variables is again used to diagnose endogeneity based on specification M6.1. As can be seen, two variables: the investment ratio and government general consumption are separately detected as endogenous, with a joint LM test statistic of 83.02. The alternative 2SLS estimate, using the same instrumental variables, is presented as M6.5. There the investment ratio becomes insignificant and even changes sign. This seems to suggest that a reverse causality from TFP to investment might be the underlying association between TFP and investment, which is hard to explain here. However, the other regression results remain unchanged.

It is clear that the conditional convergence of TFP is both strong and consistent. But its determinants are different from GDP and capital convergence, and this is likely to be explained by several factors. First, technological diffusion is primarily driven by imitation, which in turn is cheaper than invention (Barro and Sala-i-Martin, 1995; 1997). Large technological gaps and poor invention protection accelerate this process.

Second, spill over effects may be significant (Aghion and Howitt, 1998). The idea of spill over results mainly from the property of non-rivalrous of knowledge and technology. The cost and difficulty of protecting intellectual property is widely known. Consequently the explicit and implicit effects of spill over are widely observable (Romer, 1987; 1990). For example, Aghion and Howitt (1998) discuss technological spill over for leading edge technologies. The effects of spill over across countries are generally positive and supported by empirical evidence (Barro and Sala-i-Martin, 1995; 2003)

Moreover, learning-by-doing originally focuses on the improvement in productivity that arises as an enterprise gradually accumulates experience in the production process (Arrow, 1962). However, some of these improvements spill over into other firms as knowledge is assumed to be non-rival. Sheshinski (1967) and Romer (1986) discuss the accumulation of knowledge by investment, while Aghion and Howitt (1998) extend the discussion to the labour market. Barro and Sala-i-Martin (1995) combine both spill over and learning-by-doing into a system, in which growth will not be limited by diminishing returns if no limits exist to the number of new ideas to be discovered. Aghion and Howitt (1998) further argue that the growth of knowledge would follow either an adaptive model of learning that converges to a rational expectations equilibrium (Frydman and Phelps, 1983), or Bayesian models of learning by experimentation.

Finally, there is plausible evidence to support the general idea of technological convergence. Clearly the international mobility of students, labour and capital provide the means for spreading knowledge and technology. In addition, the rapid international expansion of many giant corporations not only spreads technology but also management proficiency. Even political systems, other institutions and social-economic policies are spread internationally by imitation and by the influence of the World Bank, the IMF and other international institutions.

4.6. Conclusion

This study employs the framework of conditional growth convergence of GDP to investigate three conditional convergence mechanisms: GDP growth, capital growth, and TFP growth. Firstly in auxiliary regressions, we use OECD data to show that annual data can reveal the same convergence properties as period data have done. But annual data provides more detailed information. We also found that the coefficients on educational variables were all insignificantly negative and that ignoring educational variables did not seriously bias our results.

Then we demonstrate the existence of all three conditional convergence mechanisms, though with variations in their determinants. More specifically, we find that conditional GDP and capital stock convergences are determined rather differently, but the conditional GDP and TFP convergences are less different. The investment ratio, inflation rate, general government consumption and urbanisation are significantly linked to all the three dependent variables, with the expected sign. However, openness is significantly related respectively to the change rates of TFP and per capita GDP, but not to that of capital. Meanwhile life expectancy and fertility are insignificant in the TFP and capital specifications.

Endogeneity test statistics provide further results. Three variables are endogenous in the growth convergence specification, which implies three simultaneous relationships. In contrast, two variables are endogenous in the TFP and capital convergence frameworks. Surprisingly, all the endogenous variables found in the TFP and capital regressions are completely encompassed in the conventional growth regression with general government expenditure as the common endogenous variable.

CHAPTER 5

A REVIEW OF ECONOMIC TRANSITION IN CENTRAL AND EASTERN EUROPE AND THE FORMER SOVIET UNION: WHICH POLICIES WORKED?

SUMMARY: Increased information allows a reassessment of the transition process of the economies of Central and Eastern Europe and the Former Soviet Union. Using panel data methods this paper focuses on the link between growth and structural reform during 1991-2000 within a conditional growth convergence framework. It shows that the dominant link between transition indicators and growth is negative. There is strong evidence that the level and speed of price liberalisation is negatively related to growth, as is the speed of enterprise reform. It is argued that given the specific conditions during the transition, such effects could have been expected. More reassuringly it is shown that trade liberalisation has a positive growth impact, but there is no significant link between growth and privatisation, competition policy, or financial sector reform. This does not imply that such structural reforms have failed to raise output in all transition states, nor does it deny the possibility of some longer run growth dividend. It does imply that during the first and key decade of transition, the dividend was negative. Taken as a whole the results should force a major reassessment of transition strategies.

KEY WORDS: **Transition indicators, Economic growth, Panel data**

5.1 Introduction

The past fifteen years has seen the transition from socialism to capitalism, and the consequent economic shift from centrally planned to market economies in the former Soviet Union and eastern European states. This transition, in contrast to the economic transformation of China and Vietnam, was at first accompanied by a significant output decline, followed in the second half of the 1990s by a slow recovery. It was characterised by a very complex process of transformation in institutions, economic structures and behaviour (De Melo, Cevdet and Alan, 1996). That process, a traverse between economic systems, has been so rare that initially there was no relevant economic theory. But at an empirical level a literature has emerged that explores the links between transition and growth (Merlevede, 2003; Falcetti, Raiser and Sanfey, 2002; Grogan and Moers, 2001; Aghion and Schankerman, 1999; Brenton, Daniel and Guy 1997; De Melo et al., 1996; Aghion and Blanchard 1994). This literature has tried to link progress, as measured by EBRD transition indicators, to growth - though the precise causality is elusive.

Initial conditions, macroeconomic stability and institutional and hence structural change are the main concerns in the transition literature (Falcetti et al., 2002). The mainstream growth literature shows that initial conditions are inversely related to growth – widely understood as conditional growth convergence – but that macroeconomic stability is strongly and positively related to growth (Barro, 1997; Barro and Sala-i-Martin, 2003). Initial conditions are normally captured by per capita income, with a one period lag, and macroeconomic stability is measured by the inflation rate.

There is less agreement on how to measure structural change. But assessing specific structural changes, which are mainly driven by exogenous policy changes, is also of interest because as the evolution of policy reforms can be arrayed on a scale related to the degree they mimic the development of economic systems, they can be used to compare governments' performance.

Transition indicators, such as those for liberalisation, privatisation, enterprise reform, and financial institutions, measure an economy's institutional structure and thus are likely to reflect the evolution of policy reforms. Most studies (Aghion and Schankerman, 1999; Brenton et al., 1997; De Melo et al., 1996) have found a positive correlation between growth and these indicators. Yet what most citizens of transition states remember is the economic decline that accompanied the first phases of transition.

We argue that economic performance may be affected by both the level of a transition policy, and by its rate of change. These impacts we call the "level effect" and the "speed effect". The conventional wisdom is that an increase in the level of structural reform, to more closely mimic an advanced economic system, raises output. But in practice, policies that are effective in one system may require some adaptation to succeed in another. For instance, to be effective some fundamental policy changes might demand a change in social and individual behaviour. So in itself a change of policy from one level to another does not necessarily or immediately lead to growth.

The speed at which change is introduced may have positive or negative output consequences. In the early transition years negative speed effects appeared to be common. De Melo et al. (1996), using switching regressions, gave the first econometric account. Havrylyshyn, Izvorski and van Rooden(1998) and Merlevede(2003), using lagged regressions, also provided evidence for negative early speed effects, though they cautioned that the results were not robust.

It is statistically complicated and inefficient to employ a single policy variable to represent both level and speed effects in a lagged specification - especially when the data period is as short as a decade. Some researchers assume that current and several lagged values of a variable can capture respectively the immediate and long run effects. But there is no prior information to help identify the lag order, and the short data series and loss of degrees of freedom make it impractical to conduct a test for lag order.

We use an alternative approach where the transition policy index variable reflects the level effect, and the rate-of-change of the policy index captures the speed effect. A similar rate-of-change variable was used by Heybey and Murrell(1999), but unfortunately without the original level of the transition variable. In the light of our empirical results it is likely that while they picked up the costs of transition, they are likely to have underestimated benefits.

Introducing such a variable has at least three advantages. First, a change rate is a unit free measurement. Second, it can precisely indicate the degree of the policy change. Finally, at minimum data cost it allows an investigation of short-run effects or policy shocks. Many previous studies focus on the benefits of transition, but few address costs, despite the coexistence of the two effects.

In addition structural change is multi-dimensional and ought to be measured by a range of indicators. Indicators vary in importance, so we need a general model encompassing a range of policies. But few studies explore this route, possibly due to concerns about potential problems from multicollinearity. This paper tackles these issues, using panel data methods. Our focus is on the possible relationship between transition indicators and growth, not only because these indicators have practical policy importance, but also because they provide a comparative basis to assess economic performance. We embed the relationship in an empirical model extensively employed in the growth literature. Conditioning it on commonly used variables – initial conditions, inflation and investment – provides a benchmark interpretation of the transition experience.

5.2 Methodology

The regression framework follows the conditional growth convergence approach widely used in empirical studies (Barro and Sala-i-Martin, 1991; 1992; 1995; 2003, Barro, 1997). This involves the regression of per capita growth rates on an initial condition plus a number of other explanatory variables. The initial condition is used to capture the output level of the economy, and is measured by per capita output in the previous period[1]. The evidence strongly suggests a negative relationship between the growth rate and initial condition (Havrylyshyn at el., 1998; Krueger, 1998; Berg at el., 1999; Fischer and Sahay, 2000; De Melo, Denizer, Gelb and Teney, 2001; Falcetti at el., 2002).

The other two explanatory variables are inflation, to reflect macro stability, and the share of investment in GDP. Again the existing growth literature strongly suggests that growth is positively linked to investment but negatively linked to inflation (Delong and Summers, 1991; Mankiw, Romer and Weil, 1992; Levine and Renelt, 1992; Sala-i-Martin, 1997; Havrylyshyn at el., 1998; Berg at el., 1999; Fischer and Sahay, 2000). These two variables along with the initial condition are used as control variables in our analysis.

The remaining explanatory variables, the transition indicators, in level and speed forms, largely represent exogenous policy choices, which are our focus. We later examine this exogeneity assumption, as some assert that the transition indicators are endogenous (Merlevede, 2003; Campos and Corricelli, 2002; Heybey and Murrell, 1999).

Panel data methods are extensively used in empirical growth studies, and in some transition papers (De Melo et al., 1996; Havrylyshyn et al., 1998; Berg et al., 1999; Fisher et al., 2000; Facetti et al., 2002; Merlevede, 2003). They help to

[1] Several types of initial conditions have been discussed in the transition literature (Shleifer, 1997; Krueger and Ciolko, 1998; Berg at el., 1999; and Fischer and Sahay 2000). However, per capita output or income is pre-dominant in empirical studies.

reduce small sample problems and thus the possible problem of multicollinearity. In the conditional convergence framework, our panel data model is specified as:

$$r_{i,t} = \beta_0 + \beta_1 \cdot X_{i,t} + \beta_2 \cdot Z_{i,t} + \beta_3 \cdot r_{i,t}^{Z} + u_{i,t} \tag{1}$$

$$i = 1, 2, \dots, N \text{ and } t = 1, 2, \dots, T$$

where $r_{i,t}$ is the change rate of real output; i and t denote respectively countries and periods; $X_{i,t}$ is the vector of the control variables; $Z_{i,t}$ is the set of transition indicators known as level variables; and $r_{i,t}^{Z}$ is the corresponding change rate of $Z_{i,t}$ as speed variables; β_0, β_1, β_2 *and* β_3 are parameters; and $u_{i,t}$ is the error term that can be further decomposed into a two-factor error components disturbances specification:

$$u_{i,t} = d_i + d_t + v_{i,t} \tag{2}$$

$$i = 1, 2, \dots, N \text{ and } t = 1, 2, \dots, T$$

The dummies d_i are the unobservable individual country effects, d_t are the associated unobservable time effects, and $v_{i,t}$ is an independent stochastic error term.

Treating error components d_i and d_t differently results respectively in fixed effects and random effects models. In the fixed effects case, only $v_{i,t}$ is an independent stochastic error term and both d_i and d_t are assumed to be fixed parameters that can be estimated in the model. Parameters can be estimated using least squares dummy variables (LSDV).

The random effects model treats d_i and d_t and $v_{i,t}$ as stochastically independent disturbances. Thus the relative effects of the unobservable country and time period dummy variables, as well as the variance of the error term, can be estimated and compared. The model can be estimated by generalised least squares (GLS). Although the random effects model appears to have some appealing properties it is not statistically superior to the corresponding fixed effects model. In practice a comparison can be made using the Hausman Lagrange multiplier (LM) chi-squared statistic (Hausman, 1978) [2]. A large value of the Hausman statistic favours the fixed effects model over the random one.

With a large number of variables, multi-collinearity and hence the robustness and consistency of estimates might become a problem (Levine and Renelt, 1992; Leamer 1983; 1985). Sala-i-Martin (1997) has argued that as pure robustness of parameter estimates seldom exists, we should, while retaining the concept, opt for a wider comparison of parameter significance levels. Fernandez, Ley and Steel (2001) support this view.

This paper investigates robustness in a two-stage process. First, all the variables are pooled in a regression defined by (1) and (2). Then a general to specific model reduction process, incorporating the core ideas of robust analysis from Levine and

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[2] The Hausman LM test of fixed against random panel data methods is a joint test of the differences of estimated parameters respectively from fixed and random panel data regressions.

Renelt (1992) and Sala-i-Martin (1997), is conducted, using the following procedures and criteria:

i. Starting with the general regression, all the transition variables are classified by the level of significance. Attention focuses both on the variables less than a certain significance level, say 10%, and on the least significant variable.

ii. Remove the least significant variable in the regression, and then check the impact of this on the initially significant variables. The least significant variable can be deleted if all of the initially significant variables remain so. Otherwise the insignificant variable is retained.

iii. Repeat step ii for the next least significant variable, continuing until all variables are above the chosen significance level, or until the removal of any beneath that level pulls those above it, beneath it.

iv. Conduct a joint F-test (asymptotically equivalent LM or likelihood ratio (LR) test) on the deleted insignificant variables to examine whether the model reduction process was statistically not inappropriate.

v. The deleted variables can be used as instrumental variables to reduce the endogeneity of explanatory variables[3].

The specific form has several advantages compared to the general framework. Its fewer variables reduce the risk of multicollinearity and increase the degrees of

[3] Alternative instrumentals can be lagged variables.

freedom. The screening process for variables and consequent model evolution increases the efficiency of parameter estimates. The plausibility of the model evolution process can be tested not only by the F test or equivalent LM and LR in step (iv) but also by some widely used model selection statistics, *viz.* adjusted R squared, Akaike information criterion and the Schwarz Bayesian information criterion. The Schwarz Bayesian statistic, under certain regularity conditions, is consistent and asymptotically optimal (Schwarz 1978) and will select the most parsimonious model if there are at least eight observations (Pesaran and Pesaran, 1997).

In a second stage, we use partial regression, a more parsimonious process, to check the results of the general to specific process. Each transition indicator, which is decomposed into two components - level and speed, is studied separately, conditioned on the common control variables, using the same dependent variable and panel data approach. If a variable is well behaved the results from the first and second stages will be consistent. Partial regressions also help avoid the possibility of multicollinearity between the transitional variables. If a variable is consistent between partial regression and general approaches, then the probability of a problem arising from multicollinearity between transition variables is very low, although multicollinearity is a concern when there are many explanatory variables.

Endogeneity is of wide concern in empirical studies, and is of increasing interest in studies of transition economies (Merlevede, 2003; Campos and Corricelli, 2002; Heybey and Murrell, 1999). Instead of assuming exogeneity or endogeneity, we use the Hausman LM test to check the possible endogeneity problem in the above two-stage analysis[4], and when the problem occurs tackle it with a 2SLS regression.

5.3 Data description

GDP growth rates, annual inflation rates and transition indicators are from the European Bank for Reconstruction and Development (EBRD) annual Transition Reports (EBRD, 1995; 1996; 1997; 1998; 1999; 2000; 2001; 2002). Investment as a share of GDP is from World Bank Annual Reports and World Bank Development Indicators (World Bank, 2000). The real GDP per capita in US dollars makes use of EBRD annual growth rates, World Bank data on GDP (1995 US dollars) and population.

The EBRD's Transition Report (2002) contains 37 series of indicators organised into seven dimensions. For three dimensions: infrastructure, legal environment, and the social sector there is little data. So we concentrate on the remaining four dimensions: liberalisation, privatisation, enterprises, and financial institutions - selecting two indicators for each dimension. The transition indicators are assumed to be representative of economic transition. Table 5.1 lists all variables in three categories - dependent variable, control variables, and policy variables that reflect the level and speed of indices.

[4] The specification of the Hausman test of endogeneity differs from the Hausman test of fixed against random panel data method, and can be presented equivalently as LR, LM or F tests based on a 2SLS regression.

TABLE 5.1

DESCRIPTION AND SELECTION OF VARIABLES

Code	Variable Description	Category			
		Dependent	Control	Level	Speed
R	Per capita growth rate of GDP	√			
X_1	Log of GDP per capita lagged one period		√		
X_2	Log of annual inflation rate		√		
X_3	Investment share in GDP		√		
Z_1	EBRD index of price liberalisation			√	
r^{Z_1}	Change rate of above index				√
Z_2	EBRD index of trade liberalisation			√	
r^{Z_2}	Change rate of above index				√
Z_3	EBRD index of small-scale privatisation			√	
r^{Z_3}	Change rate of above index				√
Z_4	EBRD index of large-scale privatisation			√	
r^{Z_4}	Change rate of above index				√
Z_5	EBRD index of enterprise reform			√	
r^{Z_5}	Change rate of above index				√
Z_6	EBRD index of competition policy			√	
r^{Z_6}	Change rate of above index				√
Z_7	EBRD index of banking sector reform			√	
r^{Z_7}	Change rate of above index				√
Z_8	EBRD index of reform of non-banking financial institutions			√	
r^{Z_8}	Change rate of above index				√

Twenty-five out of twenty-seven transition economies dealt with by the EBRD are included. Bosnia-Hertzgovina, and Serbia and Montenegro are excluded, due to data availability. The data set generally covers 1991-2000, but loses at least the 1991 and 1992 data points when a model with two period lagged variables is used. Economic transition was in fact launched in different countries at different times (EBRD 2000) and the early years were important in reflecting and shaping the character of the transition. Poland and Hungary began in 1989, followed in 1990 by the rest of Central and Eastern Europe (CEE) and South Eastern Europe (SEE) excluding Albania. Albania and the three Baltic States began the process in 1991, followed the following year by the twelve members of the Commonwealth of Independent States. Therefore 1991-2000 data provides a good test of transition regularities. EBRD transition indicators were introduced in 1997 and recorded by the integers 1 to 4, with pluses and minuses, valued for aggregation at 0.3, indicating slightly better or worse achievements. The 1991-1996 indices were added retrospectively by EBRD in 2000.

For a more detailed description of the data, see appendix H. The statistical descriptions of the data are presented in appendix I. The graphic descriptions of the data are presented in appendix J. The speeds of transition for individual countries are presented in appendix K.

Table 5.2 presents the correlation matrix for the variables. The correlations between economic growth and the levels of the transition indicators are positive, but those between growth and the changes in the transition indicators are negative. The absolute values of the former correlations are larger than those of the latter, except for price liberalisation. Also while the correlation coefficient between growth and inflation is large and negative, those between growth and both the initial condition and the investment share are small and respectively positive and negative. Clearly, the latter two correlation signs, associated with initial condition and investment, are inconsistent with the well-known empirical findings on conventional growth convergence (Baumol, 1986; Barro, 1997) and investments (Levine and Renelt, 1992).

TABLE 5.2 - CORRELATION MATRIX

	GDP growth rate per capita	Lagged GDP per capita	Log of inflation Rate	Investment share	Price liberalisation	Speed of price liberalisation	Trade liberalisation	Speed of trade liberalisation	Small-scale privatisation	Speed of small-scale privatisation	Large-scale privatisation	Speed of Large-scale privatisation	Enterprise reform	Speed of enterprise reform	Competition policy	Speed of competition policy	Banking reform	Speed of banking reform	Non-banking reform	Speed of non-banking reform
GDP growth rate per capita	1.000	0.026	-0.658	-0.034	0.313	-0.541	0.464	-0.326	0.537	-0.411	0.434	-0.181	0.456	-0.191	0.293	-0.173	0.451	-0.173	0.378	-0.022
Lagged GDP per capita	0.026	1.000	-0.127	0.199	0.158	-0.021	0.361	-0.108	0.397	-0.015	0.392	0.023	0.511	-0.007	0.459	0.043	0.539	0.032	0.602	0.052
Log of inflation rate	-0.658	-0.127	1.000	-0.029	-0.377	0.399	-0.632	0.313	-0.652	0.387	-0.593	0.234	-0.635	0.209	-0.380	0.177	-0.658	0.252	-0.462	0.058
Investment share	-0.034	0.199	-0.029	1.000	-0.197	0.101	-0.176	-0.071	-0.183	-0.049	0.031	0.022	0.056	-0.097	0.161	0.054	0.023	-0.020	0.161	0.031
Price liberalisation	0.313	0.158	-0.377	-0.197	1.000	-0.056	0.710	-0.062	0.670	-0.115	0.570	0.064	0.557	0.117	0.395	-0.049	0.606	0.142	0.383	0.038
Speed of price liberalisation	-0.541	-0.021	0.399	0.101	-0.056	1.000	-0.231	0.471	-0.345	0.249	-0.282	0.170	-0.304	0.038	-0.202	0.054	-0.298	0.060	-0.237	0.015
Trade liberalisation	0.464	0.361	-0.632	-0.176	0.710	-0.231	1.000	-0.045	0.817	-0.226	0.723	-0.064	0.755	0.004	0.481	-0.085	0.817	0.005	0.544	0.081
Speed of trade liberalisation	-0.326	-0.108	0.313	-0.071	-0.062	0.471	-0.045	1.000	-0.238	0.342	-0.213	0.362	-0.222	0.266	-0.167	0.111	-0.231	0.268	-0.262	0.027
Small-scale privatisation	0.537	0.397	-0.652	-0.183	0.670	-0.345	0.817	-0.238	1.000	-0.256	0.800	-0.100	0.773	-0.089	0.570	-0.060	0.798	-0.107	0.624	0.040
Speed of small-scale privatisation	-0.411	-0.015	0.387	-0.049	-0.115	0.249	-0.226	0.342	-0.256	1.000	-0.288	0.311	-0.248	0.175	-0.200	0.148	-0.270	0.125	-0.309	0.045
Large-scale privatisation	0.434	0.392	-0.593	0.031	0.570	-0.282	0.723	-0.213	0.800	-0.288	1.000	-0.035	0.781	-0.104	0.652	-0.079	0.774	-0.138	0.671	0.020
Speed of large-scale privatisation	-0.181	0.023	0.234	0.022	0.064	0.170	-0.064	0.362	-0.100	0.311	-0.035	1.000	-0.120	0.268	-0.141	0.144	-0.084	0.306	-0.275	0.035
Enterprise reform	0.456	0.511	-0.635	0.056	0.557	-0.304	0.755	-0.222	0.773	-0.248	0.781	-0.120	1.000	0.086	0.695	-0.022	0.888	-0.073	0.727	0.067
Speed of enterprise reform	-0.191	-0.007	0.209	-0.097	0.117	0.038	0.004	0.266	-0.089	0.175	-0.104	0.268	0.086	1.000	-0.110	0.235	-0.007	0.537	-0.172	0.125
Competition policy	0.293	0.459	-0.380	0.161	0.395	-0.202	0.481	-0.167	0.570	-0.200	0.652	-0.141	0.695	-0.110	1.000	0.115	0.615	-0.146	0.753	-0.009
Speed of competition policy	-0.173	0.043	0.177	0.054	-0.049	0.054	-0.085	0.111	-0.060	0.148	-0.079	0.144	-0.022	0.235	0.115	1.000	-0.010	0.179	-0.076	0.127
Banking reform	0.451	0.539	-0.658	0.023	0.606	-0.298	0.817	-0.231	0.798	-0.270	0.774	-0.084	0.888	-0.007	0.615	-0.010	1.000	0.064	0.711	0.042
Speed of banking reform	-0.173	0.032	0.252	-0.020	0.142	0.060	0.005	0.268	-0.107	0.125	-0.138	0.306	-0.073	0.537	-0.146	0.179	0.064	1.000	-0.178	0.046
Non-banking reform	0.378	0.602	-0.462	0.161	0.383	-0.237	0.544	-0.262	0.624	-0.309	0.671	-0.275	0.727	-0.172	0.753	-0.076	0.711	-0.178	1.000	0.146
Speed of non-banking reform	-0.022	0.052	0.058	0.031	0.038	0.015	0.081	0.027	0.040	0.045	0.020	0.035	0.067	0.125	-0.009	0.127	0.042	0.046	0.146	1.000

Data are from 1991 to 2000 and total observations are 225.

5.4 Results and Implications

Table 5.3 presents the results of the first stage analysis, the model reduction from general to specific form. As can be seen, M3.1 and M3.2 are respectively the model specifications of the general and the specific equation, and the overall results are consistent across the general and specific forms, but different from the correlation coefficients in table 5.2. Before exploiting the further linkages between dependent and explanatory variables, we examine the issue of model reduction and possible endogeneity problems.

First, the significance levels for all but one parameter increase from the general to specific form, which suggests that the evolution process is stable and consistent. Second, all three commonly used statistics for model selection suggest that the reduced specific form M3.2 fits the data better than the general one. Third, the small F test statistic for the joint restrictions on the reduced form also suggests that omitting the variables to produce the specific form is not inappropriate. Consequently the model evolution from the general to the specific is statistically consistent and acceptable.

Using the Hausman test there is no evidence of endogeneity problems in the explanatory variables of specifications M3.1 and M3.2. However endogeneity emerges from some of the partial regressions shown in table 5.4 in the second stage analysis. So simply for comparison we re-estimated M3.2 using two-stage least

TABLE 5.3

GENERAL-TO-SPECIFIC REGRESSION

Explanatory Variables			Specification M3.1	M3.2	M3.3
Constant term			231.02 (8.465)***	237.16 (9.679)***	295.05 (5.758)***
Control Variables	Initial condition		-30.12 (8.424)***	-31.55 (9.972)***	-38.91 (6.340)***
	Inflation rate		-2.449 (2.685)***	-2.539 (3.086)***	-0.521 (0.262)
	Investment share		0.329 (4.896)***	0.328 (5.233)***	0.360 (4.452)***
Transitional Variables	Price liberalisation	Z_1	-3.411 (2.313)**	-3.894 (2.776)***	-12.09 (1.722)*
		r^{Z_1}	-3.441 (1.974)**	-2.902 (1.760)*	0.047 (0.017)
	Trade liberalisation	Z_2	2.192 (2.075)**	2.071 (2.228)**	6.226 (1.302)
		r^{Z_2}	-1.469 (1.099)	-1.991 (1.637)	-2.242 (0.524)
	Small-scale privatisation	Z_3	-0.442(0.349)	--	--
		r^{Z_3}	-1.717 (1.089)	--	--
	Large-scale privatisation	Z_4	-1.356 (1.166)	-1.267 (1.170)	-0.455 (0.294)
		r^{Z_4}	1.997 (1.405)	1.960 (1.468)	1.182 (0.322)
	Enterprise reform	Z_5	0.057 (0.030)	--	--
		r^{Z_5}	-2.491 (1.387)	-2.611 (2.014)**	-1.707 (1.041)
	Competition policy	Z_6	-1.756 (1.067)	--	--
		r^{Z_6}	0.422 (0.259)	--	--
	Banking sector reform	Z_7	-0.112 (0.073)	--	--
		r^{Z_7}	-1.139(0.616)	--	--
	Non-banking financial reform	Z_8	-0.577 (0.412)	--	--
		r^{Z_8}	1.432 (0.905)	--	--
R^2			0.8083	0.8035	0.7981
Adjusted R^2			0.7504	0.7568	0.7501
Akaike information Criterion (AIC)			6.206	6.151	6.179
Schwarz Bayesian information Criterion			6.289	6.220	6.847
Ramsey Reset test on function form (LR)			1.107 (0.293)	0.704 (0.401)	0.811 (0.367)
F-test for joint restriction on reduced form M3.2 against M3.1			F(9, 172)=0.48(P-value=0.88)		--

Dependent variable is percentage annual growth rate. The regression method is two-way LSDV. Specification M3.3 uses the omitted transition variables as instrumental variables. t-statistics in parentheses, with * significant at 10%, ** at 5% and *** at 1%. Ramsey Reset test is likelihood ratio test statistic with p-value in parentheses. Appendix N presents the detailed results of regressions and tests of M3.1 and M3.2.

squaress (2SLS) with the variables omitted as instrumental variables[5]. The results are presented in specification M3.3.

The endogeneity in the partial regressions of table 5.4 is found in price liberalisation, trade liberalisation and large-scale privatisation. As a remedy, 2SLS using all other exogenous transition variables as instrumental variables has two consequences. On the one hand, 2SLS is expected to provide a consistent estimate of the parameter of interest. On the other hand, using instrumental variables helps to recover the information embedded in those instrumental variables. The contribution of the latter likely dominates since the number of instrumental variables is relatively large. In practice, choosing appropriate instrumental variables is often open to challenge. Therefore the results in table 5.5 are more likely pick up additional information to illustrate the whole picture of this particular transition process.

5.4.1 Control variables: initial condition, inflation rate and investment share

The three control variables help to tie these results into the mainstream growth literature, and can also be used as an informal check on possible misspecification of the model. Simultaneously a Ramsey reset test of mis-specification is also used. This is strong if indirect evidence that the model specification can reasonably simulate the reality of transitional economies. Table 5.3 shows that all the three control variables are significant with the signs expected from the mainstream

[5] The central results are consistent when alternative instrumentals are employed.

TABLE 5.4 - PARTIAL REGRESSIONS

Explanatory variables		Specification							
		M4.1	M4.2	M4.3	M4.4	M4.5	M4.6	M4.7	M4.8
Constant term***		245.40	229.67	230.96	235.94	238.38	232.72	240.63	233.86
		(10.33)	(10.44)	(10.50)	(11.53)	(11.77)	(11.38)	(11.68)	(11.16)
Control variables									
Initial condition***		-32.31	-31.67	-31.58	-31.82	-32.32	-31.26	-32.73	-31.88
		(10.42)	(10.74)	(10.71)	(11.01)	(11.32)	(10.72)	(11.16)	(10.45)
Inflation rate***		-3.395	-2.948	-3.355	-3.596	-3.413	-3.360	-3.357	-3.262
		(4.689)	(3.458)	(4.220)	(4.624)	(4.133)	(4.474)	(3.967)	(4.289)
Investment ratio***		0.335	0.308	0.309	0.319	.0.304	0.321	0.327	0.311
		(5.318)	(4.735)	(4.620)	(4.848)	(4.688)	(4.891)	(4.983)	(4.743)
Transition variables									
Price liberalisation	Z_1	-3.214^{E}							
		(2.518)**							
	r^{Z_1}	-3.636							
		(2.371)***							
Trade liberalisation	Z_2		0.613^{E}						
			(0.702)						
	r^{Z_2}		-2.262^{E}						
			(2.070)**						
Small-scale privatisation	Z_3			0.173					
				(0.159)					
	r^{Z_3}			-1.485					
				(0.976)					
Large-scale privatisation	Z_4				-1.101				
					(1.032)				
	r^{Z_4}				0.293^{E}				
					(0.221)				
Enterprise reform	Z_5					-0.518			
						(0.313)			
	r^{Z_5}					-3.006			
						(2.052)**			
Competition policy	Z_6						-2.060		
							(1.339)		
	r^{Z_6}						0.151		
							(0.096)		
Banking sector reform	Z_7							-0.461	
								(0.342)	
	r^{Z_7}							-2.176	
								(1.415)	
Non-banking financial reform	Z_8								-0.370
									(0.272)
	r^{Z_8}								1.883
									(1.192)
R^2		0.7912	0.7767	0.7727	0.7728	0.7792	0.7741	0.7751	0.7733
Adjusted R^2		0.7485	0.7310	0.7262	0.7264	0.7340	0.7279	0.7291	0.7270
Ramsey Reset test on functional form (LR)		0.274	0.083	0.045	0.061	0.286	0.120	0.152	0.102
		(0.600)	(0.772)	(0.833)	(0.805)	(0.592)	(0.729)	(0.696)	(0.749)
Hausman test on endogeniety (LM)		2.716	19.70	--	3.607	--	--	--	--
		(0.099)*	(0.000)**		(0.057)*				

Superscript ^{E} denotes the presence of endogeneity, diagnosed by a Hausman-type Lagrange multiplier test statistic with p-value in parentheses. Ramsey Reset test is the likelihood ratio test statistic, with p-value in parentheses.

literature. The hypothesis of conditional convergence and a positive relation between growth and investment are well captured by the suggested model.

Generally, there is a negative link between the inflation rate, reflecting macroeconomic stability, and growth. More specifically a high inflation rate signals a lack of government control over fiscal and monetary policy, which can not only destroy the confidence of investors but also distort the market mechanism. The hyperinflation rates observed in transition economies have been widely seen as one of the causes of economic recession during the 1990s (Berg et al., 1999). In contrast, Campos and Corricelli (2002) argue that inflation is likely a result of particular policies. While intuitively appealing, table 5.3 contains no evidence for the endogeneity of inflation.

The coefficients on the initial condition, usually interpreted in the literature as the convergence speed, are above 30% per annum. They are large compared to those of around 2.5% found by Barro (1997) and Barro and Sala-i-Martin (2003), for a sample of 90 economies. However, with a similar sample, Caselli, Esquivel and Lefort (1996) report a higher value of about 10%, justifying it with the common argument that most economies are usually close to their steady states.

With transition economies, these steady states are likely to be more volatile and are themselves partly determined by transition variables. On the other hand, for transition states in the 1990s, under generally weak government economic control, the convergence process was less constrained that in a normal market economy, and so a faster convergence was possible.

The significant positive link between investment share and growth is also widely reported in the growth literature, but the direction of causality is heavily contested (Blomstrom at el., 1996; Barro, 1997). For the transition economies, the initial output slump and high inflation severely damaged investor confidence. So it seems reasonable to posit an initial causation running from growth to investment. However, our results do not reject a causality running from investment to growth.

To sum up, these three control variables provide a consistent and convincing source of information on the transition economy. This result is in line with the second stage partial regressions shown in table 5.4. However in table 5.2, the simple correlation coefficients between growth and the control variables likely disguise a more complex reality. Taken together the results for the control variables firmly place the findings for these transition economies in the mainstream of empirical growth studies.

5.4.2 Liberalisation of prices and trade

Liberalisation is a core issue in the transition literature. This study focuses on two key aspects – price and trade liberalisation. It provides more detailed and hence more accurate information than the previously used Cumulative Liberalisation Index (CLI) suggested by De Melo et al. (1996). The CLI was a weighted average of three indicators reflecting internal markets, external markets, and private sector entry. To explore their individual impacts we study these three elements separately.

Strong negative relationships are found in both level and speed between price liberalisation and growth. These linkages are consistent in both stages of the analysis shown in tables 5.3 and 5.4, which suggest that price liberalisation was accomplished at a significant economic cost. The policy implication is that price liberalisation is not straightforward and rapid change is not directly beneficial. This view is strengthened because price liberalisation in transition economies also likely leads to the higher inflation that we have shown also damages growth.

In contrast, trade liberalisation has a positive level effect, but a negative speed effect. However, there are some inconsistencies in results between the two stages of analysis and so these results are not robust. A positive level effect is consistent with typical "Washington Consensus" advice. A negative speed effect may reflect the fact that in the early stages of the switch from plan to market foreign firms were better able to seize business opportunities. An extreme example of such liberalisation is the collapse of East German manufacturing in the wake of reunification. Even in less spectacular circumstances, a very rapid switch from administered to market prices, where the former bore little relation to real resource costs or relative demands, can result in widespread large absolute and relative price changes. The profitability of enterprises changes dramatically, and many collapse or significantly reduce their scale of output. Lobbying for state subsidies increases, but the tax base shrinks. Liberalisation in the foreign sector also leads to increased foreign competition, intensifying the contractionary effects of domestic liberalisation.

Endogeneity is found in the second stage partial regressions. As can be seen in table 5.4, the level of price liberalisation, and both the level and speed of trade liberalisation cannot pass the Hausman exogeneity test. It suggests that those three variables are likely to have been determined internally due to simultaneity problems and that instrumental variables are required for consistent estimates.

Table 5.5 shows that when instrumental variables are used, the parameter significances alter. The sign on trade liberalisation turns negative, but as before the control variables behave consistently. These results may be due to the fact that we employ a large number of instrumental variables, which implies we are more likely to recover the information rather than to provide a consistent estimate. In the former case, 2SLS provides evidence that the negative effects of transition indicators dominate, which is consistent with the results of the general-to-specific analysis.

5.4.3 Privatisation of small-scale and large-scale enterprises

Unlike the results from liberalisation, privatisation presents little clear evidence from either the partial regression or the general-to-specific approaches. As can be seen in tables 5.3 and 5.4, the small-scale privatisation indicator is negatively linked to growth in both level and speed. But both linkages are insignificant and disappear in the general-to-specific process. However the effects of large-scale privatisation are a bit stronger and both the level and speed variables survive the general to specific process, though neither variable achieves conventional levels of significance. The level effect is negative while the speed effect is positive.

TABLE 5.5

PARTIAL REGRESSION WITH INSTRUMENTAL VARIABLES (2SLS)

Explanatory variables		**Specification**		
		M5.1	**M5.2**	**M5.3**
Constant term***		299.56 (7.547)	246.29 (9.079)	242.10 (11.73)
Control variables				
Initial condition***		-38.34 (8.327)	-32.75 (10.30)	-33.08 (11.19)
Inflation rate***		-3.083 (4.243)	-3.495 (3.323)	-3.169 (3.916)
Investment ratio***		0.348 (5.489)	0.285 (4.534)	0.330 (5.030)
Transition variables				
Price liberalisation	Z_1	-6.974 (2.492)**		
	r^{Z_1}	-1.320 (0.649)		
Trade liberalisation	Z_2		-1.418 (0.754)	
	r^{Z_2}		-7.310 (3.571)**	
Large-scale privatisation	Z_4			0.107 (0.088)
	r^{Z_4}			-4.801 (1.653)*
R^2		0.7910	0.7930	0.7760
Adjusted R^2		0.7483	0.7507	0.7303
Ramsey Reset test on function form (LR)		0.108 (0.743)	0.673 (0.412)	0.183 (0.669)

It is certainly possible to argue that we should expect a negative link between large- scale privatisation and growth, as privatisation creates major social costs in the forms of unemployment, ill health, and poorer housing provision. In addition large-scale privatisation often ends in bankruptcy, though efficiency gains may be achieved by surviving firms. As privatisation may leave both firms and government with excess labour to support, this restricts both actors` ability to restructure. Even if only the profitable parts of firms are retained, in the first instance output will fall. In the longer run output may rise as the profitable divisions expand, and that might account for the positive sign on the speed variable – getting the process over more quickly pays dividends.

Endogeneity is again found in the second stage partial regressions for large-scale privatisation. As can be seen in table 5.4, the speed variable for large-scale privatisation cannot pass the Hausman test. A 2SLS estimate presented in table 5.5 shows that both the significance and sign alter, and the negative sign is highly significant, but the control variables behave consistently as before. Again this can be interpreted as a consequence of the large number of instrumental variables.

5.4.4 Enterprise reform and competition policy

Tables 5.3 and 5.4 show that the speed of enterprise reform is negatively related to growth, but there is no significant relation between its level and growth. The results of regressions of M3.1 also suggest a general negative relation between competition policy and growth, though this does not survive the general to specific process. A possible impression is that enterprise reform and competition policy produces much more pain than gain in the transition period.

Enterprise reform mainly reflects enterprise restructuring and corporate governance. Blanchard (1997) singled out restructuring as a key mechanism of transition, noting that improving productivity may also decrease employment. If restructuring is rapid then inefficient units are rapidly disbanded, and while productivity in the remaining ones may rise, overall output may fall. Our results suggest that this is exactly what happened.

Hardening the budget constraint is another key element of enterprise reform. Under planning, soft budget constraints and a complete absence of competition were the norm. So initially managers had neither experience of binding financial constraints, nor of fending off rivals. Even potentially profitable firms were thus vulnerable to their lack of experience of market discipline, and the more rapid was restructuring, the greater the risk.

Both enterprise reform and large-scale privatisation were policies aimed solely at state owned enterprises. We have already argued that the negative coefficient on the large-scale privatisation policy variable probably reflects the huge costs of layoffs in a low productivity economy. So both policy variables are picking up different aspects of the same story. The effects of competition policy, which should foster the growth of the private sector, will reinforce the negative impacts of other policies on the output of the former state sector. But here, although there is some weak evidence for this in the general regression equation, this result does not survive the general to specific process.

5.4.5 Reform of financial institutions

Banking and non-banking reform aims to produce financial institutions consonant with a market economy. Financial reform was needed to produce an efficient change in the form of assets – by channelling private savings into investment. It was also needed to generate an effective clearing system. Non-banking reform was required to ensure the growth of the complementary range of financial products that ensure more efficient inter-temporal production and consumption – from insurance to pensions. Although both sets of reforms might have been expected to increase growth, unfortunately tables 5.3 and 5.4 show little convincing evidence of this link. Indeed three of the four coefficients on these reform variables are negative, though none is significant.

Neither banking nor non-banking reform were early priorities for transition economies. Moreover the financial system under planning had limited and quite different functions to that of a market system. The functions were to check the progress of plan fulfilment, to deliver working and investment capital according to the plan, and to collect the private savings and channel them to the state, for consumption or investment. The system was a mono-bank, with no investment appraisal capabilities. After transition began the state banks were generally subjected to little competition and privatisation was often politically difficult. Although there was then a rapid growth in the numbers of new private banks, many were under-capitalised, and some, as offshoots of large cash strapped companies, did not always lend prudently. In any case the considerable uncertainty of the early transition years, allied to limited investment appraisal skills, encouraged banks to invest in government and foreign bonds, or to speculate on the stock exchanges, rather than to focus on domestic lending. In addition many states continued to use their banking system as a conduit for soft loans and other types of subsidies, as they had under planning. Consequently bad loans threatened the solvency of the system, and periodic restructuring imposed high costs on taxpayers, depositors and sometimes banks` owners. More recently tighter regulatory and supervisory regimes and increasing foreign bank penetration have significantly improved the performance of financial sectors. But given the late arrival of such improvements it is not surprising that table 5.3 records no significant positive effects from financial sector reforms.

5.5 Comparison and Extension

In this section we further examine both a methodological issue and a stability issue. First we compare our results with whose from a lagged regression. Then we investigate a possible stability issue around 1995 by splitting the sample.

5.5.1 Comparison with alternative lagged regressions

In the literature there are two alternatives to our methodology. These are switching regressions (De Melo et al., 1996), and lagged regressions (Merlevede, 2003; Havrylyshyn et al., 1998). The switching approach uses dummy variables to capture policy impacts over a certain period. This technique can be used on a single policy, but it is impossible to apply it to a continuous reform process with a range of different policies in operation.

The lagged regressions used by Merlevede (2003) and Havrylyshyn et al. (1998) employ current and two lagged terms of the policy variables to examine the policy effects. However, although in some regressions Havrylyshyn et al. (1998) found negative coefficients for the current year variables, and positive for the following two lagged periods. When more variables were introduced those results were not robust. Other drawbacks were the difficulty of identifying the lag order from a short data series, and sacrificing the early part of the series. The latter issue resulted in the loss of both degrees of freedom and information, which was of particular concern as the early transition period was likely to be the most important for understanding reform impacts on growth. Finally, by itself a lagged regression is unable to distinguish speed effects from level effects.

To show the differences between alternative models, for simplicity, we concentrate on price liberalisation. Table 5.6 presents the results from three specifications. Equation M6.1 provides the comparator that follows our methodology. The data set for this comparator is smaller than that used to derive M4.1, as the first two data points are excluded. Note also that the control variable estimates are again consistent and robust across the three different specifications.

However the estimated parameters of the policy variable are different across models. As can be seen, M6.1 is very similar to M4.1. But the lagged specification M6.2, suggests an immediate negative impact from increased price liberalisation, followed by a positive but insignificant negative effect respectively from the previous two periods. If we add a speed effect to the lagged equation, as in M6.3, this reverses the results of M6.2, but confirms the negative speed impact established in our comparator equation. Moreover, the negative level impact is significant and dominates the magnitude. The sum of the parameters of the three level variables is in fact negative. These results are consistent with our comparator. This suggests that that comparator specification is superior to the lagged versions.

TABLE 5.6

COMPARISON OF ALTERNATIVE SPECIFICATIONS

Specification		M6. 1	M6. 2	M6. 3
Control variables	*Initial condition*	36.38 (11.53)***	-38.17 (11.60)***	-35.99 (11.14)***
	Inflation rate	-3.021 (4.224)***	-3.093 (4.128)***	-3.231 (4.455)***
	Investment ratio	0.387 (6.360)***	0.381 (6.040)***	0.386 (6.324)***
Constant term		272.23 (11.19)***	287.88 (11.12)***	271.59 (10.68)***
Price liberalisation	Z_1	-2.803 (2.043)**	-7.851 (5.349)***	2.860 (0.868)
	$Z_1(-1)$	--	4.696 (3.024)***	-6.201 (1.835)*
	$Z_1(-2)$	--	-0.558 (0.503)	-0.116 (0.108)
	r^{Z_1}	-9.377 (4.449)***	--	-18.39 (3.601)***
R^2		0.8185	0.8090	0.8225
Adjusted R^2		0.7784	0.7654	0.7808
Akaike information Criterion		6.000	6.060	5.996
Schwarz Bayesian Information Criterion		6.060	6.122	6.059

5.5.2 The evidence of stabilization after 1995

By the end of the first half of 1990s, with rapid price liberalisation, most if not all of the technically easy and politically acceptable policies had been implemented and further progress in that dimension would require freeing public utility prices, and eliminating politically sensitive subsidies. By the mid 1990s it was widely accepted that prudent fiscal and monetary policies were necessary to avoid the damaging consequences of high and variable inflation rates. As a result, wild movements in macroeconomic aggregates, and often brutal but rapid transition progress were replaced by stabilisation packages and incremental changes in transition indicators. There was further turmoil and backsliding – most spectacularly in the Russian crash of 1998 – but the character of the transition process had changed. It is worth seeing if the data reflect that change.

Using a large number of dummies in the panel data analysis vitiates the widely used Chow test for coefficients' stability or structural shifts, especially when an LSDV analysis is employed. Instead, general comparisons are possible by splitting the sample, and then comparing the results from sub-samples with the full sample equation. Table 5.7 presents the estimates, where again we concentrate on a partial regression with the most promising policy variable, price liberalisation.

TABLE 5.7

COMPARISON OF STABILITY

Data set		**1991-2000**	**1991-1995**	**1996-2000**
Control variables	*Initial condition*	-32.31 (10.42)***	-37.82 (6.432)***	-45.20 (7.529)***
	Inflation rate	-3.395 (4.689)***	-2.263 (1.307)	-2.648 (2.695)***
	Investment ratio	0.335 (5.318)***	0.316 (3.219)***	0.243 (2.082)**
Constant term		245.40 (10.33)***	284.38 (6.219)***	342.65 (7.462)***
Price liberalisation	Z_1	-3.214 (2.518)**	-3.881 (1.745)*	-3.067 (1.465)
	r^{Z_1}	-3.636 (2.371)***	-2.640 (1.244)	-0.792 (0.126)
Sum of squared errors		4420.10	2317.75	955.62
R^2		0.7912	0.8153	0.6507
Adjusted R^2		0.7485	0.7216	0.5157
Akaike information Criterion		6.171	6.648	5.457
Schwarz Bayesian Information Criterion		6.234	6.651	5.483
Observations		225	102	123

Although there are clear differences between the two sub-periods, most properties remain consistent. In the early transition period, the destructive effect of the level of price liberalisation on growth is significant, though its speed, and the impact of inflation are insignificant. In the second period both the level and the speed of price liberalisation variables are less significant than in the first period, and their magnitudes are smaller. This suggests a less damaging impact in the second period. In addition, the greater sum of squared errors during 1991-1995 confirms the relatively greater volatility of the first period and thus the relative stability of the second period. The extreme volatility of inflation in the first period may even account for our failure, against the logic of the analysis of this section, to discover a significant link to growth.

5.6 Conclusions

This paper uses the framework of conditional growth convergence, to examine the impact of transition policies during 1991-2000 on central and east European states and the countries of the former Soviet Union. Panel data on eight transition indicators are decomposed into two sets of variables - level and speed - and investigated by a range of technologies. We use general-to-specific as well as partial regression in a two-stage analysis, and later compare our methods to those of earlier authors. We also examine the stabilisation process around 1995. Fortunately these comparisons do not weaken the main results, which remain plausible and striking.

First, the transition reform results are placed in the context of the standard empirical growth literature by including conditioning variables. These show a consistently significant negative link between inflation and growth; an unusually fast convergence rate; and a positive link between growth and investment as a share of GDP. Taken together these factors are more consistent and determining than the structural reform policies.

Second, it is the negative consequences of those reform policies that are dominant and significant. In particular price liberalisation has both significant negative level and speed effects on growth. The speed of trade liberalisation and the speed of enterprise reform are also negatively associated with growth. But there is a positive link between trade liberalisation and growth. No other significant links are observed.

It is important to be clear on what these results mean. They do not imply that in well functioning market systems there is no positive output effect from price liberalisation, competition policy, privatisation, enterprise or financial sector reform. They do imply that, taken as a whole, and given the ways in which such structural changes were made in transition states during 1991-2000, there was no identifiable output benefit to the policies. Our results do not imply that transition states cannot or will not benefit from such structural reforms. They do imply that they did not benefit during the first decade of transition.

CHAPTER 6. CONCLUSIONS

This thesis has empirically explored a number of growth characteristics, focusing on TFP and conditional growth convergence. Chapter 1 briefly set out the stylised facts of economic growth and the motivations of this study. In chapter 2, we then critically reviewed the theoretical developments and empirical evidence for the growth accounting and conditional convergence literature. This provided the settings for the three research topics. Chapter 3 focused on the role of TFP and the associations of TFP with the domestic and foreign R&D capital stocks, exogenous technological progress, openness and the domestic capital stock. Chapter 4 firstly challenged the consensus of conditional growth convergence, and then proposed and tested conditional capital and TFP convergences. Finally chapter 5 employed conditional convergence theory to examine a special growth phenomenon, the ten-year economic transition in Central and Eastern Europe and the Former Soviet Union during the 1990s. This chapter will summarise the findings.

6.1. Some unsettled issues

Growth accounting and conditional growth convergence are two important components of neoclassical growth theories. A large literature has been established but many issues remain unsettled. This study highlights some of the issues and a few of the topics have been explored further.

First, the conventional method of growth accounting is widely employed to provide the TFP index, though there are serious criticisms of its failure to address the quality changes of inputs (Jorgenson and Griliches, 1967; Christensen, Cummings and Jorgensen 1980; 1981; Jorgenson, Gollop and Fraumeni, 1987). In theory, Jorgenson, Gollop and Fraumeni (1987) show that growth accounting can contain a detailed decomposition of inputs into different quality categories. However in practice, it is understandable that the decomposition of the conventional inputs is mainly restricted by data availability. In fact, there are only very limited exercises of growth accounting fully addressing the quality changes of inputs (Jorgenson and Griliches, 1967; Christensen, Cummings and Jorgensen 1980; 1981; Jorgenson, Gollop and Fraumeni, 1987). In effect, the only exceptions are growth accounting exercises for the USA.

Second, a recent literature has suggested positive effects of domestic and foreign R&D variables on TFP (Coe and Helpman 1995; Keller 1998; Kao, Chiang and Chen 1999; and Edmond 2001). However, there are few studies examining whether the findings of Coe and Helpman (1995) are sensitive to the inclusion of additional variables, in particular, a time trend reflecting exogenous technological progress and a physical capital stock reflecting an externality. Barro (1999), Durlauf and Quah (1999), and Barro and Sala-i-Martin (2003) show that TFP encompasses a broad range of elements such as, labour augmented technological progress, capital augmented technological progress, capital stock externality, research and development, and human capital. In addition, Griliches (1973) shows that the time trend reflecting exogenous technological progress is a significant determinant of TFP.

Third, Barro and Sala-i-Martin (1992) and Mankiw, Romer, and Weil (1992) developed the theories of conditional growth convergence, emphasizing different perspectives. The MRW model of Mankiw, Romer, and Weil (1992), emphasising human capital, is widely used to test the augmented Solow model (Mankiw, Romer and Weil 1992; Islam 1995; Caselli, Esquivel and Lefort 1996; and Temple 1998). In contrast, Barro and Sala-i-Martin (1992) address the role of consumers' preference. Later on, Barro and Lee (1994), Barro and Sala-i-Martin (1995), Barro (1997), Barro and Sala-I-Martin (2003) empirically employ a general convergence framework to explore the effects of a broad range of variables. Caselli, Esquivel and Lefort (1996) suggest favouring the flexible general framework. We argue that the MRW model is a special case of the general convergence framework. An immediate advantage of the general framework is the convenience of comparison with the large amount of empirical evidence available in the existing literature.

Fourth, a majority of empirical studies in the convergence literature explore period average data rather than annual data, though the annual data contain more information. It is undeniable that period data allow us to investigate some variables not available on annual frequencies. One of such variables is the proxy of human capital, in particular, educational attainment and schooling. Lucas (1988; 1990), and Mankiw, Romer and Weil (1992) argue that ignoring human capital can seriously bias the results of our analysis. However, few studies seriously examine this argument within the general convergence framework. In the growth convergence literature, we have not found a single study that compares the difference in results of using period and annual data. .

Fifth, the empirical evidence from educational variables is not consistent, even with the same data set. For example, Mankiw, Romer and Weil (1992), Barro and

Lee (1994), Barro (1997), and Barro and Sala-i-Martin (2003) suggest that the educational variables positively relate to growth. However after controlling the country differences in the MRW model, Islam (1995) and Caselli, Esquivel and Lefort (1996) reported negative coefficients on educational variables. Barro and Sala-i-Martin (1995) and Caselli, Esquivel and Lefort (1996) even report completely opposite signs respectively from male and female educational variables.

Last but not least, there is no agreement on the speed of growth convergence. Barro and Sala-i-Martin (1992), Mankiw, Romer and Weil (1992), Barro and Sala-i-Martin (1995; 2003), calibrating from theories, show the convergence speed of the USA is above 4 per cent around the steady state. However, their cross-section regressions suggest that the convergence speed during the transition period is only around 2 per cent. This is in contradiction to the theoretical prediction that the convergence speed is faster the further an economy is from its steady state. In contrast, Islam (1995) and Caselli, Esquivel and Lefort (1996) reported higher convergence speed from cross-section regressions by controlling for country differences.

6.2. The role and characteristics of TFP

The role of TFP has been examined, based on the conventional growth accounting approach, with the data on 16 OECD countries during 1961-1997. We show that TFP in general explains a large part of economic growth. Among the selected countries, we find that the USA experiences the least TFP progress. This can be explained by the general technological leadership of the USA, whose TFP progress mainly depends on genuine research and innovation. As a result, the USA has only a relatively small opportunity to learn, imitate and copy technologies from others. By contrast, the TFP progress of Japan is the fastest. This might reflect the significant role of technological imitation and transfusion in the 1960s and 1970s. In addition, we find that Ireland, Greece and Italy achieved TFP progress above the average. By contrast, Sweden, the UK, the Netherlands, Denmark, and Luxembourg are below the average. These results overall suggest a catching up process with TFP progress greatest in poorer countries and vice versa, although a possible slight exception is Japan in the 1980s and 1990s.

Although Coe and Helpman (1995) have suggested that the domestic and foreign R&D capital stocks are significant and positive associated with TFP in a one-factor panel data analysis, we find that such relationships are not consistent. This has been demonstrated in three ways. Firstly, the relationships are sensitive to two key variables: the time trend representing the exogenous technological progress and the capital stock reflecting capital stock externality. On the one hand, adding either of them, the coefficients on domestic R&D capital stock became insignificant. Including both variables, the coefficient even became significant negative. On the other hand, the coefficients on the foreign domestic R&D capital stock are all significant and negative when either the time trend or capital stock is added.

Secondly, the relationships are sensitive to lagged variables. Introducing the lagged dependent variable and lagged domestic and foreign R&D capital stocks, we find that the coefficients on current domestic R&D capital stock are insignificant and positive and that on current foreign R&D capital stock is significantly negative. We also find that the coefficients on the current and corresponding lagged explanatory variables have similar magnitude but opposite sign. As a result, the overall effects of domestic and foreign R&D capital stocks are largely cancelled out.

Thirdly, the relationships do not survive even after we control time difference by using a two-factor panel data method. Once more the coefficients on the foreign R&D capital stock are significant and negative. Those on the domestic R&D capital stock are insignificant without the capital stock variables. Adding the capital stock variables produces a significant negative coefficient on the domestic R&D capital stock. Clearly, these results seriously challenged the findings of Coe and Helpman (1995) – a positive association between TFP and R&D capital stocks.

Interestingly, the time trend, the capital stock and the interactive term between openness and foreign R&D capital stock behave robustly through alternative regressions. All the coefficients on them are positive though those on the interaction term are slightly insignificant when lagged variables are introduced. In particular, the newly added variable, the time trend, performs rather consistently. The estimated time dummies in two-factor panel data analysis show clearly an upward time trend. As the time trend is associated with exogenous technological progress - an important element in explaining TFP (Griliches 1973; Barro and Sala-i-Martin 2003) - we argue that ignoring it likely biases the analysis of Coe and Helpman (1995). This study clearly supports this argument.

We also show that the capital stock, the second variable newly added, is significantly related to TFP in most regressions. Its coefficients are consistently positive. This provides new evidence that the capital stock delivers a positive externality to growth. Such an effect was demonstrated in theory by Barro (1999) and Barro and Sala-i-Martin (2003) and had been examined practically by Griliches (1979).

The interaction term between openness and the foreign R&D capital stock is found to be positively associated with TFP, though is less significant as lagged variables are introduced. The standard explanation of the interaction term is measuring the marginal effect of the foreign R&D capital stock as an economy becomes more open. Coe and Helpman (1995) use it to capture the effects of trade-related spillovers. This study confirms the beneficial effects of the trade-related spillovers reported by Coe and Helpman (1995).

As proposed in this thesis, the characteristics of TFP progress have been further investigated in a conditional convergence framework. Using alternative proxies of the level of TFP, and with a sample of 16 selected OECD countries, chapter four demonstrates consistent convergence of TFP progress. It also examines a number of possible determinants of TFP. First, the effect of the inflation rate on TFP is found to be significant and negative. As the inflation rate reflects the stability or fluctuation of an economy, this result shows that economic stability is good for TFP progress. Second, the openness represented by total trade over GDP is found positively to impact on TFP progress. This shows that foreign trade has beneficial effects on TFP. Third, a significant positive effect of urbanisation on TFP is also reported. As urbanisation denotes the economic scale and infrastructure, the results suggest economic scale and infrastructure positively affect TFP progress. Using Hausman's exogeneity test, all the above three explanatory variables passed the test.

However, two explanatory variables, the investment ratio to GDP and the general government consumption ratio to GDP, are found to be endogenous. Using two-stage LSDV with instruments, a significant negative effect of general government consumption has been consistently found. As the government general consumption channels away a great deal of resources from the production sector, the negative consequence is expected. In contrast, the coefficient on the investment ratio to GDP became insignificant as instruments are employed.

In addition, life expectancy is found negatively to affect TFP progress, though it is insignificant in some regressions. For the sample studied, it is understandable that the life expectancy variable largely reflects the economic burden of an aging society, rather than the human capital suggested by some studies. The negative coefficients on life expectancy also suggest that an economy has to spend a large part of its resources to look after elderly people in an aging society. However no clear association between fertility rate and TFP is found. This is unsurprising for it is difficult to imagine a clear link between fertility and TFP in developed countries.

6.3. The features of convergence mechanisms

Chapter four challenges the consensus of conditional growth convergence using general conditional convergence regression. As previous studies use period data to explore the properties of conditional growth convergence, this study has explored annual data, which provided rather consistent convergence evidence. Using auxiliary regressions in which annual data are transformed into period data, we show that annual data can reveal the same convergence properties as period data have done. But annual data provides more detailed information.

Both theories and some empirical studies suggest that education is a key growth determinant (Lucas 1988; 1990; Mankiw, Romer and Weil 1992; and Barro and Sala-i-Martin 2003). This study, employing four alternative educational variables provided by Barro and Lee (2001), has shown that there is no significant association between any educational variables and growth. Instead we found that the coefficients on educational variables are all negative. This finding is consistent with the results of Islam (1995) and Caselli, Esquivel and Lefort (1996).

Mankiw, Romer and Weil (1992) suggest that ignoring educational variables seriously biases the results in the MRW model. This study, using the general conditional convergence framework, has shown that the exclusion of educational variables has no significant impact on the coefficients of other explanatory variables. It is undeniable that addressing educational variables is one major reason for using period data. The finding of this study to some extent allows the exploration of annual data without being concerned that we are thereby neglecting educational variables.

This study provides new evidence supporting higher convergence coefficients. As most studies report a low convergence coefficient (Barro and Sala-i-Martin 1992; Mankiw, Romer and Weil 1992; Barro and Lee 1994; Barro 1997), they faced an unexplainable dilemma, for theories expect a higher convergence speed. With the results reported in this study, the dilemma is resolved. Our results are also consistent with those of Islam (1995) and Caselli, Esquivel and Lefort (1996). Indeed all the later analysis supporting higher convergence coefficients employ more statistically preferable methods.

The analysis of the conditional convergence framework has also revealed further interesting results. Though most coefficients on explanatory variables are consistent with the existing literature, we found that the coefficient on life expectancy was negatively related to growth. As life expectancy is well in excess of retirement age in our sample countries, higher life expectancy largely represents the economic burden of aging societies, which is expected to be related negatively to growth. The positive coefficients on urbanisation, a newly added variable, suggest beneficial effects to growth perhaps from economic size, the agglomeration effects and the provision of infrastructure.

We also conducted an exogeneity test for all the explanatory variables. There is serious concern about causality, but few empirical studies in convergence studies have attempted to examine it. Our results suggest that the inflation rate, the investment ratio to GDP, and the general government consumption ratio to GDP cannot pass Hausman's exogeneity test. The concerns of endogeneity about these three variables were addressed by Barro (1997), though he did not conduct any statistical test.

Furthermore, we have proposed and tested the conditional capital stock convergence, as Barro and Sala-i-Martin (1999; 2003) demonstrate that conditional growth convergence is equivalent to capital stock convergence. Though capital stock convergence is consistently captured in this thesis, there is no empirical evidence supporting the equivalence of the above two convergences. Instead we found that the previous period capital stock and GDP growth are significant in the capital stock convergence framework. In addition, we could not find a significant relationship between capital stock growth and openness, life expectancy, or the fertility rate.

After further proposing a conditional TFP convergence framework that has already been summarised in 6.1, it is not difficult to show that the three conditional convergence mechanisms all existed but were differently determined. As the inflation rate, the investment ratio to GDP, and the ratio of general government consumption to GDP were found to be endogenous in growth convergence, the investment ratio to GDP and the general government consumption ratio to GDP were endogenous in capital stock convergence, and the investment ratio and general government consumption were diagnosed to be endogenous in TFP convergence.

6.4. The characteristic of transition economies

Chapter five employs a conditional convergence framework to explore the economic performance of the transition economies in the 1990s. There are few theories that address the specific transition process from a centrally planned to a free market economy. Most empirical studies simply investigate the relationship between economic growth and a number of explanatory variables, in particular, the transition indicators (Merlevede 2003; Falcetti, Raiser and Sanfey 2002; Grogan and Moers 2001; Aghion and Schankerman 1999; Brenton, Daniel and Guy 1997; De Melo et al. 1996). As initial conditions and the inflation rate are commonly used in both growth and transition literatures, we introduced the general convergence framework to accommodate the empirical transition studies with per capita growth rate as dependent variable. The lagged per capita GDP, inflation rate and investment ratio to GDP are used as control variables. The focus of our work is the EBRD transition indicators.

This study also decomposed each transition indicator into a level variable and a speed variable. Most studies only examine the level variable. Very few studies address the speed variable. The exception is Heybey and Murrell (1999), but they unfortunately dropped the level variable. We employed both level and speed variables for each transition indicator. Because of the sensitivity of the method, we examined each transition indicator separately and jointly, conditioned on the three control variables, using a two-stage analysis.

The overall results are striking. The coefficients on the three control variables are consistent with the results of mainstream growth literature (see chapter four). But we found that the dominant link between transition indicators and growth was negative. There is strong evidence that the level and speed of price liberalisation is negatively related to growth, as is the speed of enterprise reform. Clearly, given the fact of the significant fall of output and the specific conditions during the transition, such effects could have been expected. Interestingly we found that trade liberalisation had a positive growth impact, but there was no significant link between growth and privatisation, competition policy, or financial sector reform.

Moreover, we also conducted exogeneity tests. There is currently no such an exercise in the transition literature. In the general-to-specific analysis, all the explanatory variables can pass Hausman's test. However, in the second stage partial regressions, some variables associated with price liberalisation, trade liberalisation and large-scale privatisation are diagnosed to be endogenous. Using two-stage LSDV, the analysis further confirms the overall negative relationship between transition indicators and growth.

The results do not suggest that such structural reforms have failed to raise output in all transition states, nor do they deny the possibility of some longer run growth benefits. They do imply that during the first and key decade of transition, the massive transition cost may have overrun the limited dividend. Taken as a whole the results should force a major reassessment of transition strategies.

6.5. Concluding remarks

Clearly, our findings set out above may seriously alter the consensus of the growth literature in many aspects. It is undeniable that the empirical results of this thesis are largely associated with the two data sets developed during the preparation of this thesis. The first data set, probably the higher quality set, covers 16 selected OECD countries for the period 1960-1997. The second comprises the unique data used to reflect specific transition phenomena. The results generated from those two data sets, in particular the second, are hence restricted to the sample countries we have studied. However, the methodologies presented in this thesis can be easily extended to explore new data sets.

APPENDIX A

TECHNICAL NOTES ON PANEL DATA METHODS

A panel data regression is distinguished from a regular time-series and cross-section regression in that a panel data regression is specified as:

$$y_{i,t} = \alpha + X'_{i,t}\beta + u_{i,t} \qquad \textbf{(A-1)}$$

$i = 1, 2, \ldots, N$ and $t = 1, 2, \ldots, T$

where i denotes countries, t denotes time or period. α is a scalar, β is Kx1 and $X_{i\,t}$ is the *i*th observation on K explanatory variables. $u_{i\,t}$ can be decomposed into a two-factor error components model:

$$u_{i,t} = d_i + d_t + v_{i,t} \qquad \textbf{(A-2)}$$

$i = 1, 2, \ldots, N$ and $t = 1, 2, \ldots, T$

where d_i indicates the unobservable individual country effect while d_t indicates the associated unobservable time effect, and $v_{i,t}$ is the remaining independent stochastic error term. In this specification, d_i is time invariant and accounts for an individual country specific effect that is not included from the regression. d_t is country invariant and accounts for any time specific effect excluded in the regression. Treating error components for d_i and d_t differently results respectively in fixed effects and random effects models. In the fixed effects case, v_{it} is the only independent stochastic error term while both d_i and d_t are assumed to be fixed parameters – they are coefficients of country and time dummies that can be estimated in the model.

A one-factor error component model is a special case of a two-factor error components model from which the time specific component d_t is excluded. So the model can be simplified as:

$$u_{i,t} = d_i + v_{i,t} \qquad \textbf{(A-3)}$$

$$i = 1, 2, \ldots, N \text{ and } t = 1, 2, \ldots, T$$

Clearly, the regular time-series and cross-section regressions are other special cases of the two-factor components model from which both country and time specific components d_i and d_t are excluded.

These notes sketch the core ideas of panel data methods and a number of test statistics. I avoid using the less accessible but more compact Kronecker product. For detailed development of the literature, see the cited work. There is no single source covering all the technologies presented here.

A.1. A one-factor fixed panel data model

Least squares dummy variables (LSDV) is commonly used to estimate the fixed effect panel data regression. It is also known as within regression. To illustrate the LSDV method, we start with a simple one-factor panel data regression defined by equations (A-1) and (A-3).

$$y_{i,t} = \alpha + \beta' x_{i,t} + d_i + v_{i,t} \qquad \textbf{(A-4)}$$

averaging all the variables over time, we have:

$$\bar{y}_{i,.} = \alpha + \beta' \bar{x}_{i,.} + d_i + \bar{v}_{i,.} \qquad \textbf{(A-5)}$$

Then subtracting (A-5) from (A-4) helps to wipe out those time-invariant variables, and hence we get:

$$y_{i,t} - \bar{y}_{i,.} = \beta \ (x_{i,t} - \bar{x}_{i,.}) + (v_{i,t.} - \bar{v}_{i,.}) \qquad \textbf{(A-6)}$$

Finally averaging over all observations in (A-4), we obtain:

$$\bar{y}_{.,.} = \alpha + \beta \ \ \bar{x}_{.,.} + \bar{v}_{.,.} \qquad \textbf{(A-7)}$$

In this case, $\hat{\beta}$ can be estimated from regression (A-6) by ordinary least squares, $\hat{\alpha}$ can be recovered from (A-7), and $\hat{d}_i$ from (A-5). There is a restriction $\sum_{i=1}^{N} d_i = 0$ automatically imposed to avoid the dummy variable trap or perfect multicollinearity. Otherwise $\hat{\alpha}$ and $\hat{d}_i$ cannot be separately estimated.

A simple Chow test can be employed to test the joint significance of the countries' dummies – a test for fixed effects - based on regression (A-4). This is the standard F-test. The null and alternative hypotheses are respectively:

H_0 : $d_1 = d_2 = \ldots\ldots = d_{N-1} = 0$.

H_1 : $d_i \neq 0$ for $i = 1, 2, \ldots, N-1$.

The F-test statistic is given by:

$$\frac{(RRSS - URSS)/(N-1)}{URSS/(NT - N - K)} \overset{H_0}{\sim} F([N-1],[N(T-1)-K]) \qquad \textbf{(A-8)}$$

where RRSS is the restricted residual sums of squares associated with the regular cross section regression and URSS is the unrestricted residual sums of squares associated with (A-4). Two alternative likelihood tests – Lagrange multiplier (LM) and Likelihood ratio (LR) – can provide equivalent decisions. They are both asymptotically χ^2(N-1) under H_0 and the LM test is also known as the score test.

A.2. A one-factor random effects panel data model

The corresponding random effects model treats both d_i and $v_{i,t}$ as stochastically independent disturbances. For simplicity, we have to impose assumptions such as:

$$E(d_i) = E(v_{i,t}) = 0 \qquad \textbf{(A-9)}$$

$$Var(v_{i,t}) = \sigma_v^2 \qquad \textbf{(A-10)}$$

$$Var(d_i) = \sigma_d^2 \qquad \textbf{(A-11)}$$

$$Cov(d_j, v_{i,t}) = 0 \qquad \textit{for all j, i, and t} \qquad \textbf{(A-12)}$$

$$Cov(v_{i,t}, v_{j,s}) = 0 \qquad \textit{if } i \neq j, \textit{ or } t \neq s \qquad \textbf{(A-13)}$$

$$Cov(d_i, d_j) = 0 \qquad \textit{if } i \neq j \qquad \textbf{(A-14)}$$

Generalised least squares (GLS) could be used to estimate the random effects model if we knew the two variances in equations (A-10) and (A-11). Practically feasible generalised least squares (FGLS) is used, as those two variances can be estimated from the above LSDV regression. Clearly from equation (A-6), we have:

$$E\left[\sum_{t=1}^{T} (v_{i,t.} - \bar{v}_{i,.})^2\right] = (T-1)\sigma_v^2(i) \qquad \textbf{(A-15)}$$

after an adjustment for the degrees of freedom, an unbiased estimator of $\sigma_v^2(i)$ is given as:

$$\hat{\sigma}_v^2(i) = \frac{1}{T-k-1}\sum_{t=1}^{T} (\hat{v}_{i,t.} - \hat{\bar{v}}_{i,.})^2 \qquad \textbf{(A-16)}$$

Averaging such estimators over all the countries, and after further correction for the degrees of freedom, we get:

$$\hat{\sigma}_v^2 = \frac{1}{NT - N - k} \sum_{i=1}^{N} \sum_{t=1}^{T} (\hat{v}_{i,t.} - \hat{\bar{v}}_{i,.})^2 \tag{A-17}$$

From equation (A-5), we have:

$$Var(d_i + \bar{v}_{i,.})^2 = \sigma_d^2 + \frac{\sigma_v^2}{T} \tag{A-18}$$

Based on equation (A-5) and after a corresponding correction for the degrees of freedom, we then get:

$$\hat{Var}(d_i + \bar{v}_{i,.}) = \frac{(\hat{d_i + \bar{v}_{i,.}})'(\hat{d_i + \bar{v}_{i,.}})}{N - K} \tag{A-19}$$

Substituting equations (A-17) and (A-19) into (A-18), we finally obtain:

$$\hat{\sigma}_d^2 = \hat{Var}(d_i + \bar{v}_{i,.}) - \frac{\hat{\sigma}_v^2}{T} \tag{A-20}$$

Breusch and Pagan (1980) suggest a Lagrange multiplier (LM) test for the random effects. The null and alternative hypotheses are respectively:

$H_0: \sigma_d^2 = 0$

$H_1: \sigma_d^2 \neq 0$

The LM test statistic is given by:

$$LM = \frac{NT}{2(T-1)} \left[\frac{\sum_{i=1}^{N} \left(\sum_{t=1}^{T} \hat{v}_{i,t} \right)^2}{\sum_{i=1}^{N} \sum_{t=1}^{T} \hat{v}^2_{i,t}} - 1 \right]^2 \overset{H_0}{\sim} \chi^2(1) \tag{A-21}$$

Hausman's specification test is widely used to compare the random effects against the fixed effects estimators, following Hausman (1978). The null and alternative hypotheses are respectively:

$H_0: \; E(u_{i,t}/X_{i,t}) = 0$

$H_1: \; E(u_{i,t}/X_{i,t}) \neq 0$

Hausman (1978) suggests comparing $\hat{\beta}_{FGLS}$ and $\hat{\beta}_{LSDV}$ which are respectively random and fixed effects estimators. Both of them are consistent under the null hypothesis, while they will have different probability limits if the null hypothesis is not true. Regardless of the truth or falsity of the null hypothesis, the fixed effects estimator is consistent. In contrast, the random effects estimator is inconsistent when the alternative hypothesis is true. The Hausman test statistic is given by:

$$(\hat{\beta}_{FGLS} - \hat{\beta}_{LSDV})'\left[Var(\hat{\beta}_{FGLS} - \hat{\beta}_{LSDV})\right]^{-1}(\hat{\beta}_{FGLS} - \hat{\beta}_{LSDV}) \overset{H_0}{\sim} \chi^2(k) \qquad \textbf{(A-22)}$$

where k is the dimension of the slope vector β.

A.3. A dynamic panel data model

An alternative specification of the one-factor error component model is its dynamic presentation, as, for simplicity, in the following first-order model:

$$y_{i,t} = \alpha + \beta' x_{i,t} + \delta' y_{i,t-1} + d_i + v_{i,t} \qquad \textbf{(A-23)}$$

A problem arises in the estimation of such a model, in which the lagged dependent variable is correlated with the disturbance term, even if the assumption (A-13) is fully satisfied. A general approach that has been developed in the literature is the instrumental variables estimator estimated by the generalised method of moments

(GMM). This is based on the first differences of equation (A-23), by which the country dummies are swept from the model:

$$y_{i,t} - y_{i,t-1} = \beta'(x_{i,t} - x_{i,t-1}) + \delta'(y_{i,t-1} - y_{i,t-2}) + v_{i,t} - v_{i,t-1} \qquad \textbf{(A-24)}$$

If the time series is assumed to be long enough, the predetermined lagged levels, $y_{i,t-2}$, $y_{i,t-3}$, and the lagged differences, $(y_{i,t-2} - y_{i,t-3})$ can be used as instrumental variables. The lagged levels are preferable, although there are a number of options for the instruments. The moment conditions for the construction of a GMM estimator can be given by:

$$\frac{1}{N}\sum_{i=1}^{N} y_{i,s}\left[(y_{i,t} - y_{i,t-1}) - \beta'(x_{i,t} - x_{i,t-1}) - \delta'(y_{i,t-1} - y_{i,t-2})\right] = 0 \qquad \textbf{(A-25)}$$

$s = 0, 1, \ldots, t-2$ and $t = 2, 3, \ldots, T$

There are T(T-1)/2+T-2 such moment conditions (Arellano and Bond 1991; Ahn and Schmidt 1995; Baltagi 2005). Bhargarva and Sargan (1983) and Arellano and Bond (1991) suggest Sargan's test statistic for the over-identification of the instrumental variables. The null and alternative hypotheses are respectively:

H_0 : over-identifying restrictions are satisfied.

H_1 : over-identifying restrictions are not satisfied.

To compute Sargan's test, one has to present all the moment conditions given by (A-25). For simplicity, we need to rewrite all the moment conditions in matrix forms as:

$$E(W_i' \Delta v_i) = 0 \qquad \textbf{(A-26)}$$

where

$$W_i = \begin{bmatrix} y_{i,1} & & & & 0 \\ & y_{i,1}, y_{i,2} & & & \\ & & \cdot & & \\ & & & \cdot & \\ & & & & \cdot \\ 0 & & & & y_{i,1}, y_{i,2}, \dots, y_{i,T-2} \end{bmatrix} \quad \text{(A-27)}$$

$$\Delta v_i = v_{i,t} - v_{i,t-1} = (y_{i,t} - y_{i,t-1}) - \beta'(x_{i,t} - x_{i,t-1}) - \delta'(y_{i,t-1} - y_{i,t-2}) \quad \text{(A-28)}$$

Sargan's test of over-identifying restriction is given by:

$$(\Delta \hat{v})' W \left[\sum_{i=1}^{N} W_i'(\Delta \hat{v}_i)((\Delta \hat{v}_i)' W_i \right]^{-1} W'(\Delta \hat{v}) \overset{H_0}{\sim} \chi^2(p-k-1) \quad \text{(A-29)}$$

where p is the number of columns of W.

A.4. A two-factor fixed panel data model

As two-factor error components model is specified, LSDV method is employed to estimate the fixed panel data regression defined by equations (A-1) and (A-2).

$$y_{i,t} = \alpha + \beta' x_{i,t} + d_i + d_t + v_{i,t} \quad \text{(A-30)}$$

Averaging all the variables over individual countries, we have:

$$\bar{y}_{.,t} = \alpha + \beta' \bar{x}_{.,t} + d_t + \bar{v}_{.,t} \quad \text{(A-31)}$$

A restriction $\sum_{t=1}^{T} d_t = 0$ is automatically imposed to avoid the dummy variable trap. A linear combination of equations (A-30), (A-31), (A-5), and (A-7) gives:

$$y_{i,t} - \bar{y}_{i,.} - \bar{y}_{.,t} + \bar{y}_{.,.} = \beta\ (x_{i,t} - \bar{x}_{i,.} - \bar{x}_{.,t} + \bar{x}_{.,.}) + (v_{i,t.} - \bar{v}_{i,.} - \bar{v}_{.,t} + \bar{v}_{.,.}) \quad \text{(A-32)}$$

Analogous to model (A-6), $\hat{\beta}$ can be estimated from regression (A-32) by OLS, $\hat{\alpha}$ can be recovered from (A-7), and $\hat{d}_i$ and $\hat{d}_t$ are given respectively by:

$$\hat{d}_i = (\bar{y}_{i,.} - \bar{y}_{.,.}) - \hat{\beta}\ (\bar{x}_{i,.} - \bar{x}_{.,.}) \qquad \textbf{(A-33)}$$

$$\hat{d}_t = (\bar{y}_{.,t} - \bar{y}_{.,.}) - \hat{\beta}\ (\bar{x}_{.,t} - \bar{x}_{.,.}) \qquad \textbf{(A-34)}$$

In contrast to the Chow test for fixed effects in the one-factor fixed panel data model, the joint significance of the dummy variables can be tested by a number of F test statistics, depending on the null and alternative hypotheses. To test for overall fixed effects, the null and alternative hypotheses are respectively:

H_0 : $d_1 = d_2 = \ldots\ldots = d_{N-1} = 0$ and $d_1 = d_2 = \ldots\ldots = d_{T-1} = 0$.

H_1 : $d_i \neq 0$ for I=1, 2, … , N-1 or $d_t \neq 0$ for t = 1, 2, … , T-1.

The F-test statistic is given by:

$$\frac{(RRSS - URSS)/(N + T - 2)}{URSS/((N-1)(T-1) - K)} \overset{Ho}{\sim} F([N + T - 2],[(N-1)(T-1) - K]) \qquad \textbf{(A-35)}$$

where RRSS is the restricted residual sums of squares associated with the regular time-series and cross-section regressions and URSS is the unrestricted residual sums of squares associated with (A-30). Two alternative likelihood tests – Lagrange multiplier (LM) and Likelihood ratio (LR) – can provide equivalent decisions. They are both asymptotically χ^2(N+T-2) under H_0.

To test for fixed country effects allowing for time effects, the null and alternative hypotheses are respectively:

H_0 : $d_1 = d_2 = \ldots\ldots = d_{N-1} = 0$ and $d_t \neq 0$ for t = 1, 2, … , T-1.

H_1 : $d_i \neq 0$ for i=1, 2, … , N-1 and $d_t \neq 0$ for t = 1, 2, … , T-1.

The F-test statistic is given by:

$$\frac{(RRSS - URSS)/(N-1)}{URSS/((N-1)(T-1) - K)} \overset{Ho}{\sim} F([N-1],[(N-1)(T-1) - K]) \qquad \textbf{(A-36)}$$

where RRSS is the restricted residual sums of squares associated with time-series dummies only, and URSS is the unrestricted residual sums of squares associated with (A-30). Two alternative likelihood tests – Lagrange multiplier (LM) and Likelihood ratio (LR) – can provide equivalent decisions. They are both asymptotically χ^2(N-1) under H_0.

Analogous to test for fixed time effects allowing for individual country effects, the null and alternative hypotheses are respectively:

H_0 : $d_1 = d_2 = \ldots\ldots = d_{T-1} = 0$ and $d_i \neq 0$ for i = 1, 2, … , N-1.

H_1 : $d_t \neq 0$ for t = 1, 2, … , T- 1 and $d_i \neq 0$ for I=1, 2, … , N-1.

The F-test statistic is given by:

$$\frac{(RRSS - URSS)/(N-1)}{URSS/((N-1)(T-1)-K)} \overset{Ho}{\sim} F([T-1],[(N-1)(T-1)-K]) \qquad \textbf{(A-37)}$$

where RRSS is the restricted residual sums of squares associated with country dummies only, and URSS is the unrestricted residual sums of squares associated with (A-30). Two alternative likelihood tests – Lagrange multiplier (LM) and Likelihood ratio (LR) – can provide equivalent decisions. They are both asymptotically χ^2(T-1) under H_0.

A.5. A two-factor random panel data model

The corresponding random effects model treats d_i, d_t, and $v_{i,t}$ as stochastically independent disturbances. For simplicity, we have to impose the following assumptions:

$$E(d_i) = E(d_t) = E(v_{i,t}) = 0 \qquad \textbf{(A-38)}$$

$$Var(v_{i,t}) = \sigma_v^2 \tag{A-39}$$

$$Var(d_i) = \sigma_N^2 \tag{A-40}$$

$$Var(d_t) = \sigma_T^2 \tag{A-41}$$

$$Var(u_{i,t}) = \sigma_v^2 + \sigma_N^2 + \sigma_T^2 \qquad \textit{for all i and t} \tag{A-42}$$

$$Cov(u_{i,t}, u_{j,s}) = \begin{cases} \sigma_N^2 & i = j, \quad t \neq s \\ \sigma_T^2 & i \neq j, \quad t = s \\ 0 & i \neq j, \quad t \neq s \end{cases} \tag{A-43}$$

This means that the correlation coefficient

$$Correl(u_{i,t}, u_{j,s}) = \begin{cases} \sigma_N^2 / (\sigma_N^2 + \sigma_T^2 + \sigma_v^2) & i = j, \quad t \neq s \\ \sigma_T^2 / (\sigma_N^2 + \sigma_T^2 + \sigma_v^2) & i \neq j, \quad t = s \\ 1 & i = j, \quad t = s \\ 0 & i \neq j, \quad t \neq s \end{cases} \tag{A-44}$$

Generalised least squares (GLS) could be used to estimate the random effects model if we knew the three variances in equations (A-39), (A-40) and (A-41). In practice, feasible generalised least squares (FGLS) is used, as those three variances can be estimated from the corresponding LSDV regressions. Firstly from equation (A-32), we have:

$$\hat{\lambda}_1 = \hat{\sigma}_v^2 = \frac{1}{(N-1)(T-1)-k} \sum_{i=1}^{N} \sum_{t=1}^{T} (\overset{\frown}{v_{i,t} - \overline{v}_{i,.} - \overline{v}_{.,t} + \overline{v}_{.,.}})^2 \tag{A-45}$$

Secondly from the equation,

$$\overline{y}_{i,.} - \overline{y}_{.,.} = \beta \; (\overline{x}_{i,.} - \overline{x}_{.,.}) + (\overline{v}_{i,.} - \overline{v}_{.,.}) \tag{A-46}$$

we have:

$$\hat{\lambda}_2 = T\hat{\sigma}_T^2 + \hat{\sigma}_v^2 = \frac{1}{N-k-1}\sum_{i=1}^{N} (\overline{\hat{V}}_{i,.} - \overline{V}_{.,.})^2 \tag{A-47}$$

Thirdly from the equation,

$$\bar{y}_{.,t} - \bar{y}_{.,.} = \beta\ (\bar{x}_{.,t} - \bar{x}_{.,.}) + (\bar{v}_{.,t} - \bar{v}_{.,.}) \tag{A-48}$$

we get:

$$\hat{\lambda}_3 = N\hat{\sigma}_N^2 + \hat{\sigma}_v^2 = \frac{1}{T-k-1}\sum_{t=1}^{T} (\overline{\hat{V}}_{.,t} - \overline{V}_{.,.})^2 \tag{A-49}$$

And finally from equations (A-45), (A-47) and (A-49), we obtain:

$$\hat{\sigma}_N^2 = \frac{1}{T}(\hat{\lambda}_2 - \hat{\sigma}_v^2) \tag{A-50}$$

$$\hat{\sigma}_T^2 = \frac{1}{N}(\hat{\lambda}_3 - \hat{\sigma}_v^2) \tag{A-51}$$

Breusch and Pagan (1980) suggest a Lagrange multiplier (LM) test for the overall random effects. The null and alternative hypotheses are respectively:

$H_0:\ \sigma_N^2 = \sigma_T^2 = 0$

$H_1:\ \sigma_N^2 \neq 0 \quad and \quad \sigma_T^2 \neq 0$

The LM test statistic is given by:

$$LM = LM_1 + LM_2 \overset{H_0}{\sim} \chi^2(2) \tag{A-52}$$

where

$$LM_1 = \frac{NT}{2(T-1)}\left[\frac{\sum_{i=1}^{N}\left(\sum_{t=1}^{T}\hat{v}_{i,t}\right)^2}{\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{v}^2_{i,t}} - 1\right]^2 \overset{H_0}{\sim} \chi^2(1) \tag{A-53}$$

$$LM_2 = \frac{NT}{2(N-1)}\left[\frac{\sum_{i=1}^{T}\left(\sum_{t=1}^{N}\hat{v}_{i,t}\right)^2}{\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{v}^2_{i,t}} - 1\right]^2 \overset{H_0}{\sim} \chi^2(1) \qquad \textbf{(A-54)}$$

Similar to the application of Hausman's test in the one-factor random panel data model, Hausman's specification test is used to compare the random effects against the corresponding fixed effects estimators, following Hausman (1978). The null and alternative hypotheses are respectively:

H_0 : $E(u_{i,t}/X_{i,t}) = 0$

H_1 : $E(u_{i,t}/X_{i,t}) \neq 0$

Hausman (1978) suggests comparing $\hat{\beta}_{FGLS}$ and $\hat{\beta}_{LSDV}$ which are respectively random and fixed effects estimators. The Hausman test statistic is given by:

$$(\hat{\beta}_{FGLS} - \hat{\beta}_{LSDV})'\left[Var(\hat{\beta}_{FGLS} - \hat{\beta}_{LSDV})\right]^{-1}(\hat{\beta}_{FGLS} - \hat{\beta}_{LSDV}) \overset{H_0}{\sim} \chi^2(k) \qquad \textbf{(A-55)}$$

where k is the dimension of slope vector β.

A.6. Hausman's test for exogeneity

Hausman's test is also known as the Durbin-Wu-Hausman test following Durbin (1954), Wu (1973), and Hausman (1978) in the literature. There are a number of applications of Hausman's tests. In contrast to the Hausman test for the random effects estimators versus the corresponding fixed effects estimators, Hausman's test is often employed to test the exogeneity of explanatory variables (Pesaran and Pesaran 1997; and Davidson and Mackinnon 2005). For the two-factor fixed panel data regression, the null and alternative hypotheses for the Hausman test are specified as:

$H_0: \; E(u_{i,t}/X_{i,t}) = 0$

$H_1: \; E(u_{i,t}/Z_{i,t}) = 0$

where $Z_{i,t}$ are instrumental variables. Under H_1, the LSDV instrumental variables estimator $\hat{\beta}_{IV-LSDV}$ is consistent, but the $\hat{\beta}_{LSDV}$ is not. Under H_0, both are consistent. Therefore, plim($\hat{\beta}_{IV-LSDV}$ - $\hat{\beta}_{LSDV}$) is zero under the null and nonzero under the alternative hypothesis. The central idea of the Hausman test is to test whether the difference $\hat{\beta}_{IV-LSDV}$ - $\hat{\beta}_{LSDV}$ is significantly different from zero in the sample. The Durbin-Wu-Hausman test statistic is given by

$$(\hat{\beta}_{LSDV} - \hat{\beta}_{IV-LSDV})'\left[Var(\hat{\beta}_{LSDV} - \hat{\beta}_{IV-LSDV})\right]^{-1}(\hat{\beta}_{LSDV} - \hat{\beta}_{IV-LSDV}) \overset{H_0}{\sim} \chi^2(k) \quad \textbf{(A-56)}$$

where k is the number of potentially endogenous variables.

A.7. Ramsey RESET test

Ramsey's RESET test of functional form is primarily under linear versus nonlinear assumptions. It is commonly used in time series analysis to test whether power transforms need to be added to the model. It is also used to test if there are no omitted variables. For the two-factor fixed panel data regression, Ramsey test statistic is a test of zero restriction on the coefficient of $\hat{y}^2{}_{i,t}$ in the following auxiliary regression.

$$y_{i,t} = \alpha + X_{i,t}^{'}\beta + \delta \cdot \hat{y}_{i,t}^{2} + u_{i,t} \quad \textbf{(A-57)}$$

where $\hat{y}_{i,t}$ is the fitted value of $y_{i,t}$. Clearly, Ramsey test is the F-test, the LM, or the LR test.

A.8. Akaike information criterion (AIC) and Schwarz Bayesian Criterion (SBC)

There are a number of model selection criteria measuring the fitness of a given model by its maximised value of the log-likelihood function, in which different penalty functions are used to take account of the effects of the number of unknown parameters. Akaike information criterion (AIC) and Schwarz Bayesian Criterion (SBC) are frequently employed in econometric analysis and hence often provided by some econometric packages. Limdep automatically calculates AIC by the following equation:

$$AIC = -\frac{2}{NT}(\log L - k - 1) \tag{A-58}$$

where log$L$ is the maximised value of the log-likelihood function, and k is number of parameters. The corresponding SBC can be computed by the equation below:

$$SBI = -\frac{2}{NT}(\log L - \frac{k+1}{2}\log(NT)) \tag{A-59}$$

APPENDIX B

DATA SOURCES AND DEFINITIONS FOR CHAPTER 3

The data in chapter three are from World Bank (2000), European Commission (2002) and Coe and Helpman (1995).

GDP growth rate, total labour force, import share, and gross domestic fixed investments are from World Bank (2000). They cover the period 1961-1997. First, GDP growth rate is the annual percentage growth rate of GDP at market prices based on constant local currency. Second, total labour force comprises people who meet the International Labour Organization definition of the economically active population: all people who supply labour for the production of goods and services during a specified period. It includes both the employed and the unemployed. Third, import share is the sum of imports of goods and services measured as a share of gross domestic product. Imports of goods and services represent the value of all goods and other market services provided to or received from the rest of the world. Finally, gross domestic fixed investment includes land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including commercial and industrial buildings, offices, schools, hospitals, and private residential dwellings.

Unemployment rates and labour shares are from the European Commission (2002). They cover the period 1961-1997. Unemployment refers to the share of the labour force that is without work but available for and seeking employment. Labour shares are adjusted wage shares defined as the compensation per employee as a percentage of GDP at factor cost per person employed.

Domestic and Foreign R&D capital stocks are constructed by Coe and Helpman(1995). These annual data consists of 21 OECD countries plus Israel during the period 1971-90. The 21 OECD countries are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Greece, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, West Germany, U.K. and U.S.A. The domestic R&D capital stock is the estimate of business sector research and development capital stocks based on R&D expenditure data from the OECD's Main Science and Technology Indicators, except for Israel's which is from the November 1990 Supplement to the Monthly Bulletin of Statistics. The foreign R&D capital stock is constructed as a weighted sum of the cumulative R&D expenditures of the country's trading partners in which the weights are given by the bilateral import shares. For more details, see Coe and Helpman's appendix for the definition and construction of these two variables.

APPENDIX C

DESCRIPTIVE STATISTICS OF THE DATA FOR CHAPTER 3

Variable Description	Sample size	Descriptive statistics					
		Mean	S.D.	Skewness	Kurtosis	Min	Max
Annual growth rate of GDP	592	3.556	2.799	0.303	3.961	-7.070	12.900
Annual growth rate of labour input	592	0.716	1.465	-0.116	4.550	-5.090	5.880
Annual growth rate of capital stock	592	3.568	2.076	1.067	4.663	-1.020	13.100
Labour share	592	72.137	4.888	0.338	3.854	53.700	96.100
Unemployment rate	592	5.480	4.280	1.437	2.558	0.000	24.100
Annual growth rate of TFP	592	2.032	2.410	0.172	4.324	-8.270	11.100
Import share	300	30.224	14.638	0.698	2.959	5.680	73.000
TFP index	300	0.949	0.086	-0.155	3.019	0.703	1.202
Domestic R&D capital stock index	300	0.839	0.291	0.128	3.030	0.094	1.757
Foreign R&D capital stock index	300	0.854	0.200	0.196	2.432	0.423	1.444
Capital stock index	300	0.891	0.164	-0.469	2.805	0.407	1.292

Note. S.D. is Standard Deviation.

APPENDIX D

GRAPHICAL DESCRIPTION OF THE VARIABLES FOR CHAPTER 3

Fig. D-1A. Growth Variables for Belgium (61-97)

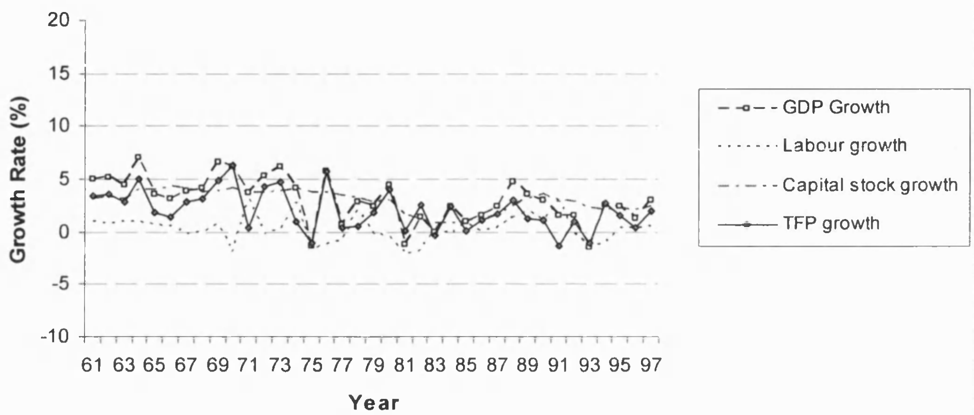


Fig. D-1B. Labour and Import Shares for Belgium (61-97)

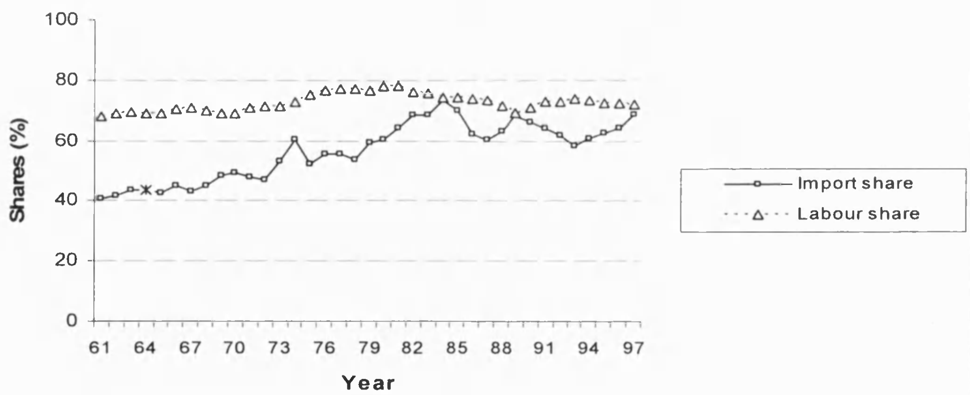
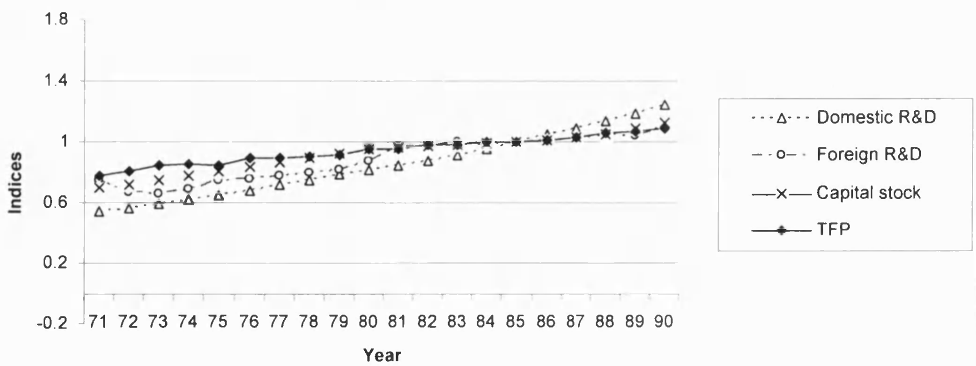


Fig. D-1C. Four Indices for Belgium (71-90)



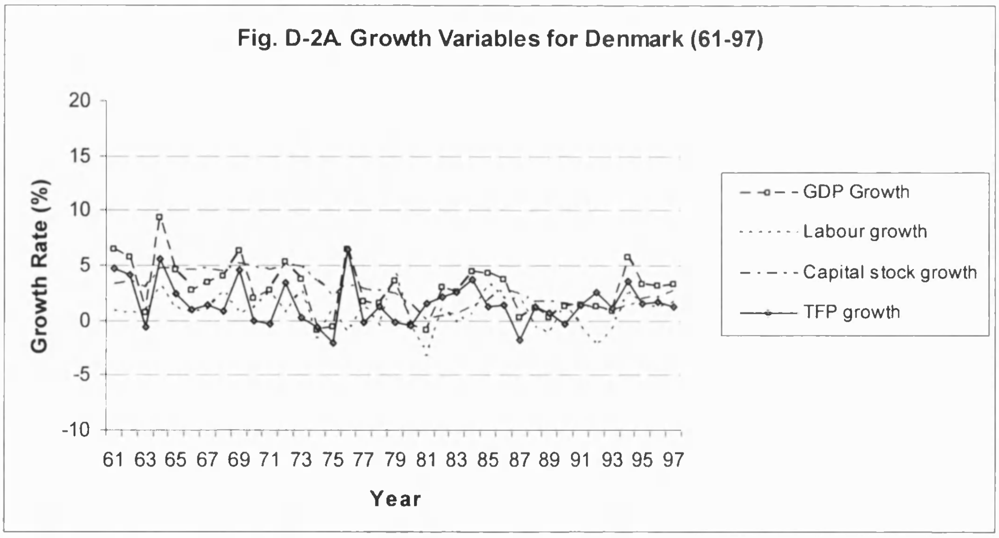


Fig. D-2A Growth Variables for Denmark (61-97)
Growth Rate (%)
20
15
10
5
0
-5
-10
61 63 65 67 69 71 73 75 77 79 81 83 85 87 89 91 93 95 97
Year
GDP Growth
Labour growth
Capital stock growth
TFP growth

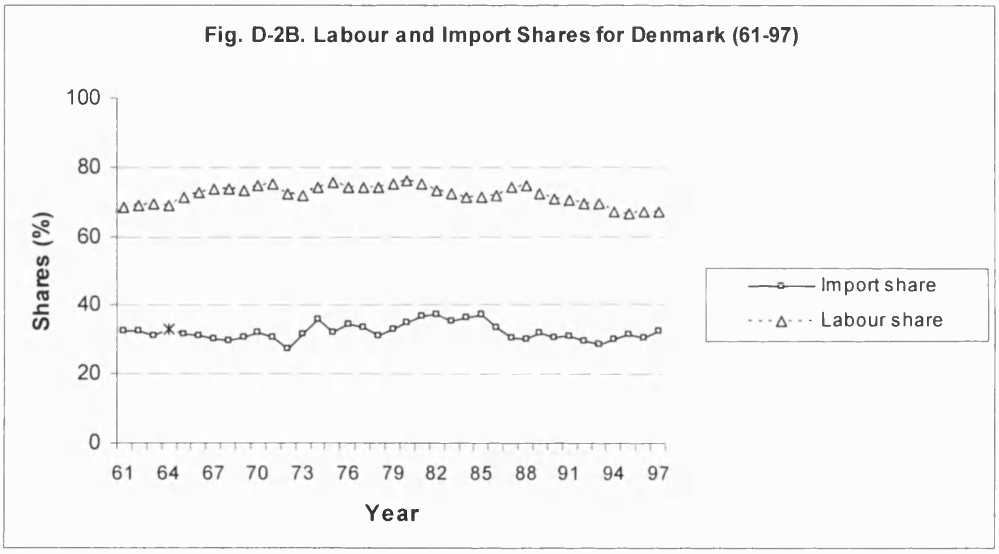


Fig. D-2B. Labour and Import Shares for Denmark (61-97)
Shares (%)
100
80
60
40
20
0
61 64 67 70 73 76 79 82 85 88 91 94 97
Year
Import share
Labour share

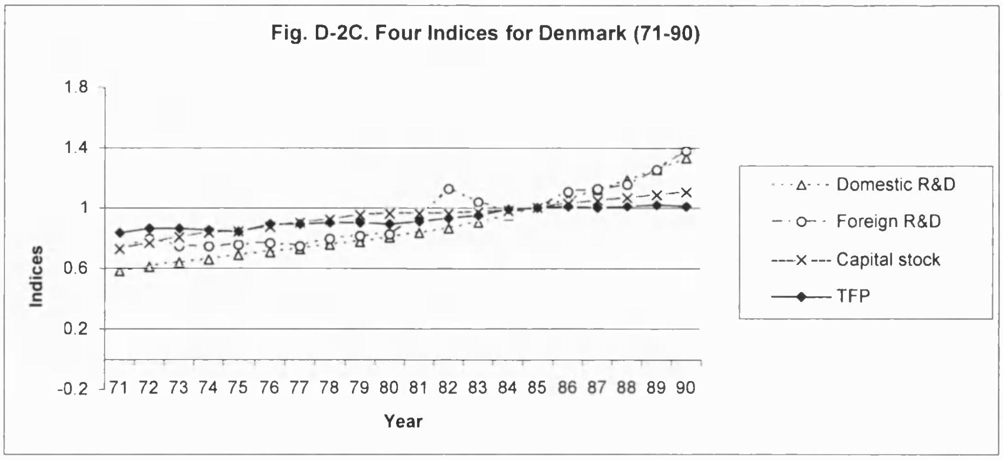


Fig. D-2C. Four Indices for Denmark (71-90)
Indices
1.8
1.4
1
0.6
0.2
-0.2
71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90
Year
Domestic R&D
Foreign R&D
Capital stock
TFP

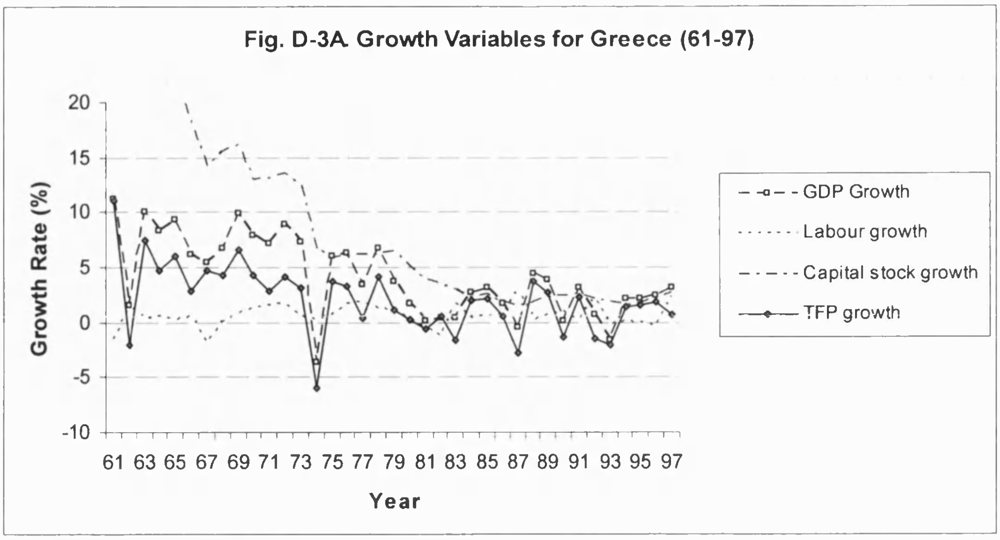


Fig. D-3A. Growth Variables for Greece (61-97)
Growth Rate (%)
Year
GDP Growth
Labour growth
Capital stock growth
TFP growth

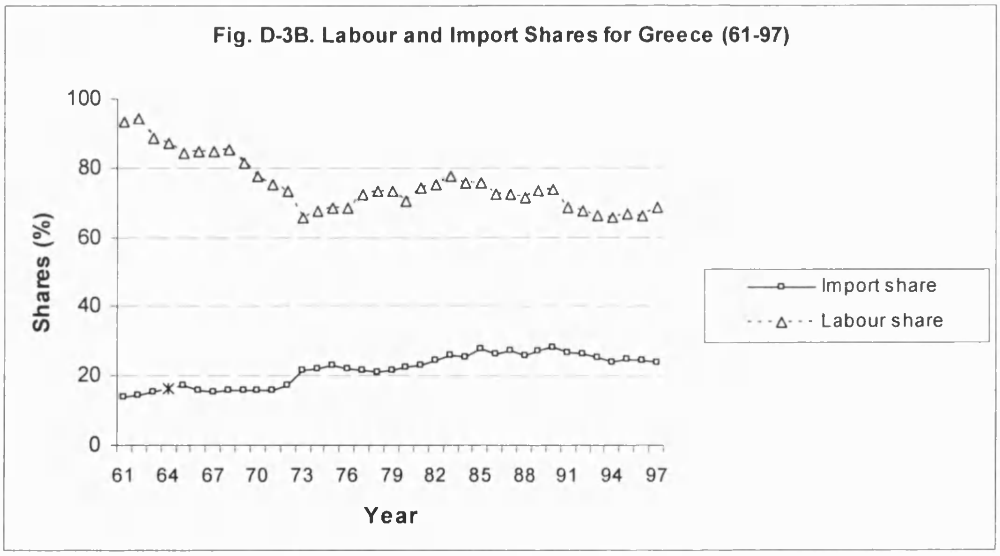


Fig. D-3B. Labour and Import Shares for Greece (61-97)
Shares (%)
Year
Import share
Labour share

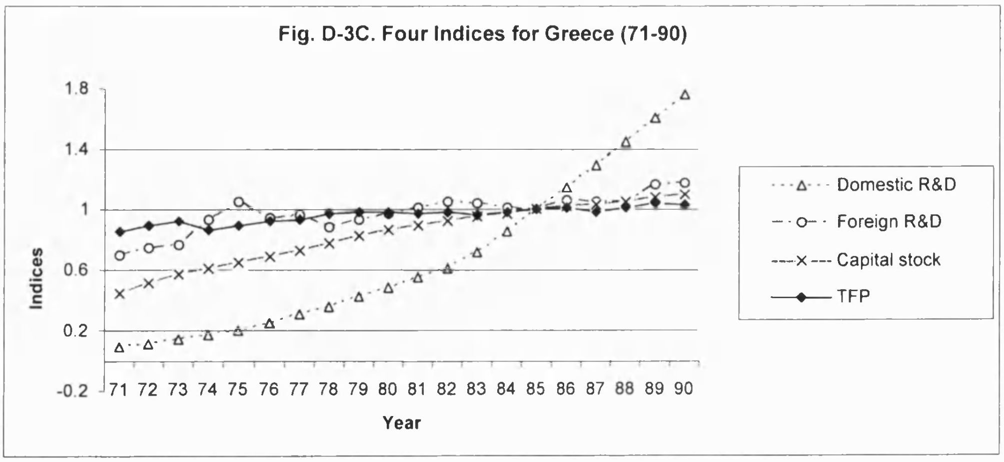


Fig. D-3C. Four Indices for Greece (71-90)
Indices
Year
Domestic R&D
Foreign R&D
Capital stock
TFP

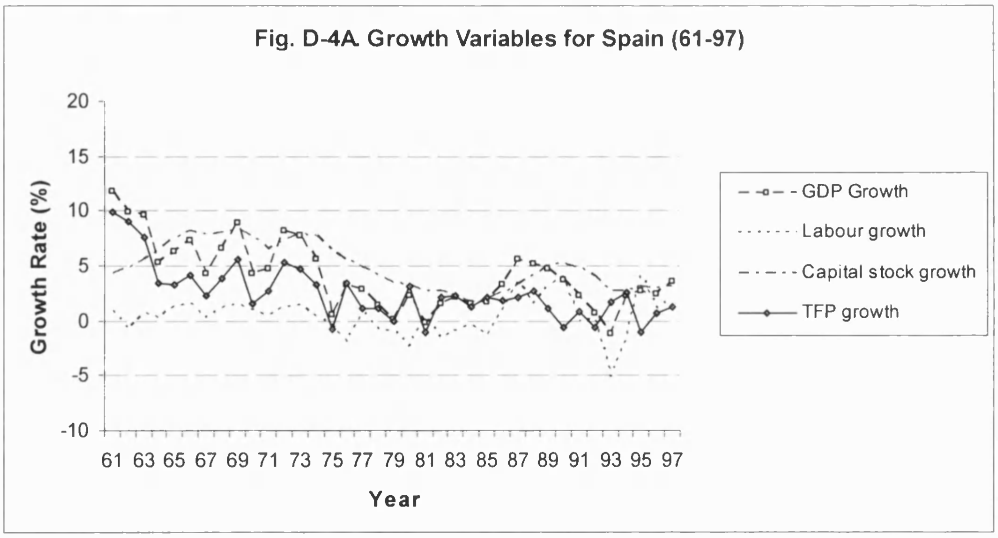


Fig. D-4A. Growth Variables for Spain (61-97)
Growth Rate (%)
Year
GDP Growth
Labour growth
Capital stock growth
TFP growth

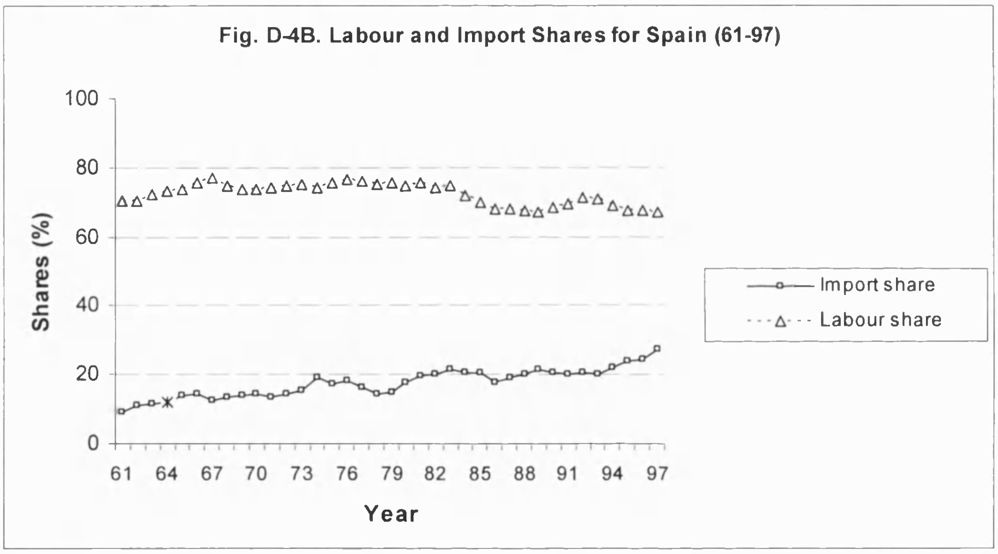


Fig. D-4B. Labour and Import Shares for Spain (61-97)
Shares (%)
Year
Import share
Labour share

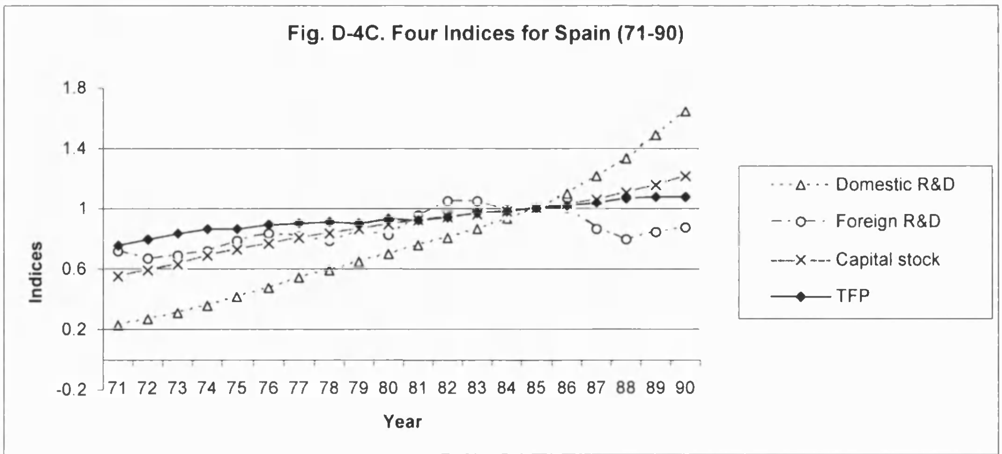


Fig. D-4C. Four Indices for Spain (71-90)
Indices
Year
Domestic R&D
Foreign R&D
Capital stock
TFP

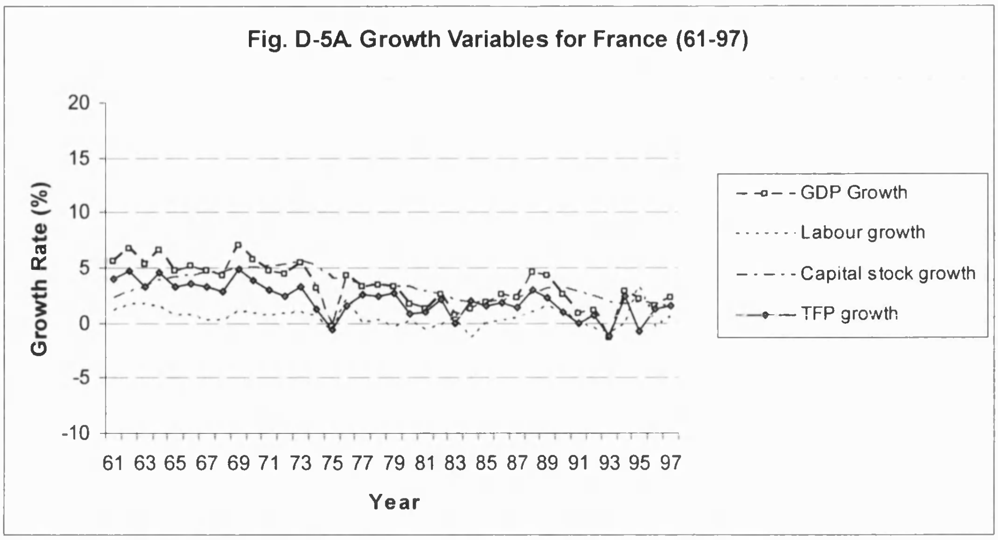


Fig. D-5A. Growth Variables for France (61-97)
Growth Rate (%)
20
15
10
5
0
-5
-10
61 63 65 67 69 71 73 75 77 79 81 83 85 87 89 91 93 95 97
Year
GDP Growth
Labour growth
Capital stock growth
TFP growth

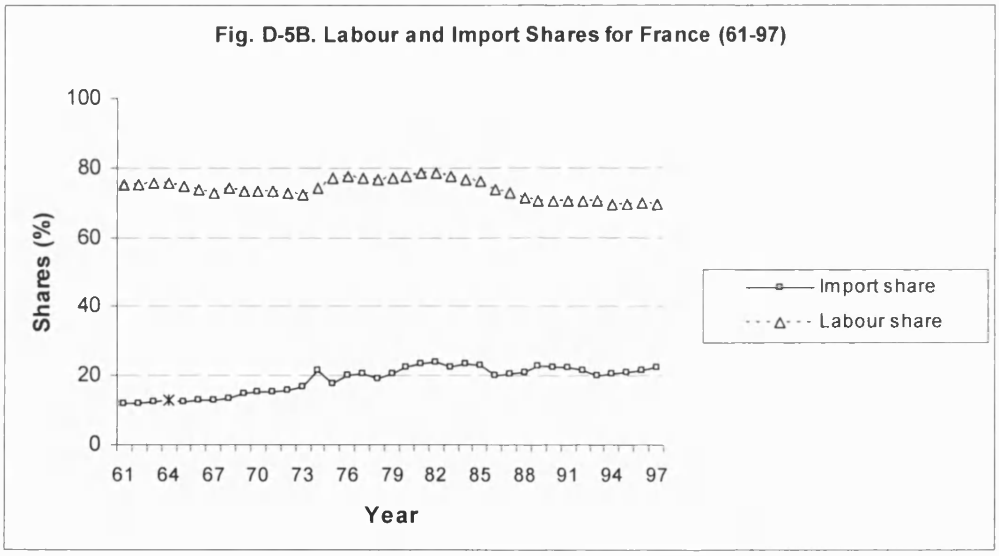


Fig. D-5B. Labour and Import Shares for France (61-97)
Shares (%)
100
80
60
40
20
0
61 64 67 70 73 76 79 82 85 88 91 94 97
Year
Import share
Labour share

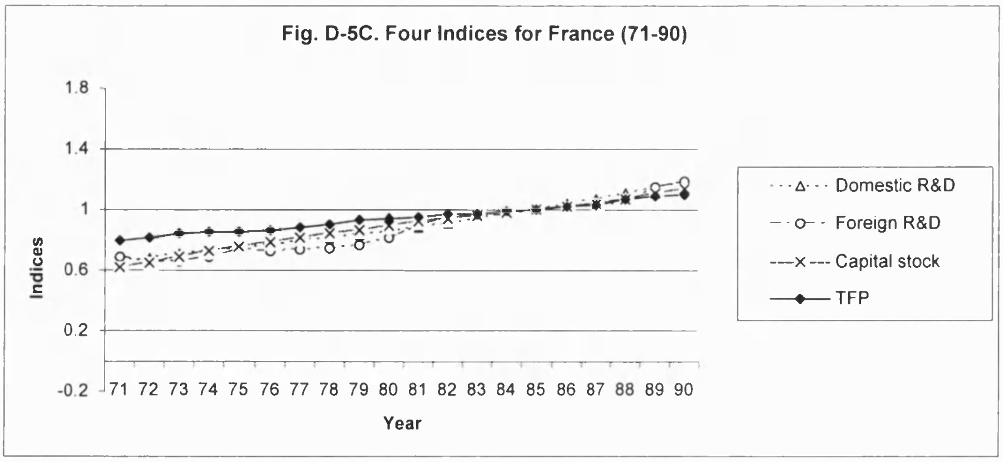


Fig. D-5C. Four Indices for France (71-90)
Indices
1.8
1.4
1
0.6
0.2
-0.2
71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90
Year
Domestic R&D
Foreign R&D
Capital stock
TFP

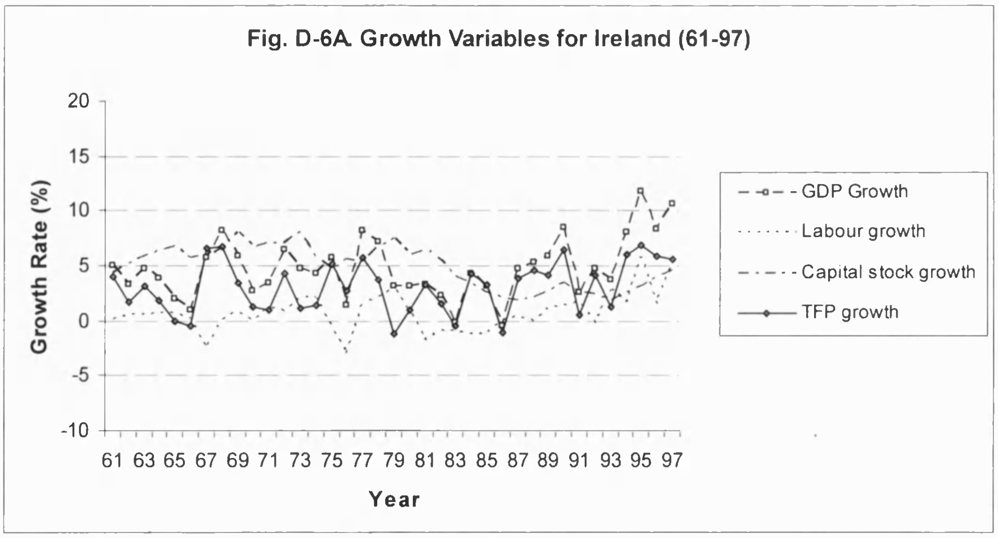


Fig. D-6A. Growth Variables for Ireland (61-97)
Growth Rate (%)
20
15
10
5
0
-5
-10
61 63 65 67 69 71 73 75 77 79 81 83 85 87 89 91 93 95 97
Year
GDP Growth
Labour growth
Capital stock growth
TFP growth


Fig. D-6B. Labour and Import Shares for Ireland (61-97)
Shares (%)
100
80
60
40
20
0
61 64 67 70 73 76 79 82 85 88 91 94 97
Year
Import share
Labour share

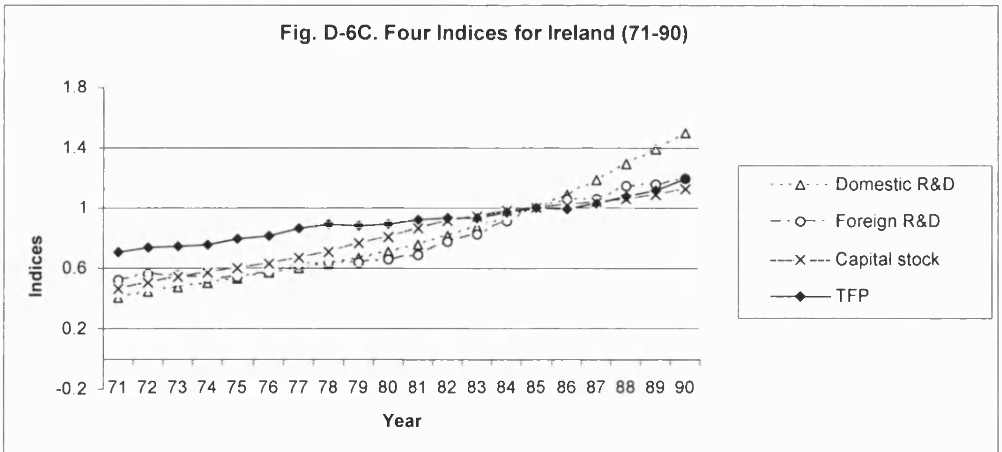


Fig. D-6C. Four Indices for Ireland (71-90)
Indices
1.8
1.4
1
0.6
0.2
-0.2
71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90
Year
Domestic R&D
Foreign R&D
Capital stock
TFP

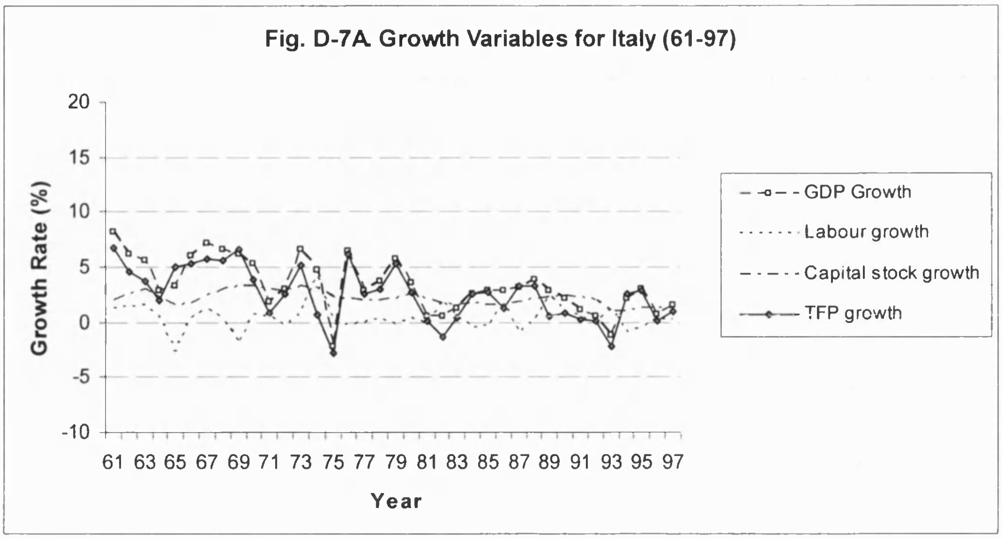


Fig. D-7A. Growth Variables for Italy (61-97)
Growth Rate (%)
Year
GDP Growth
Labour growth
Capital stock growth
TFP growth

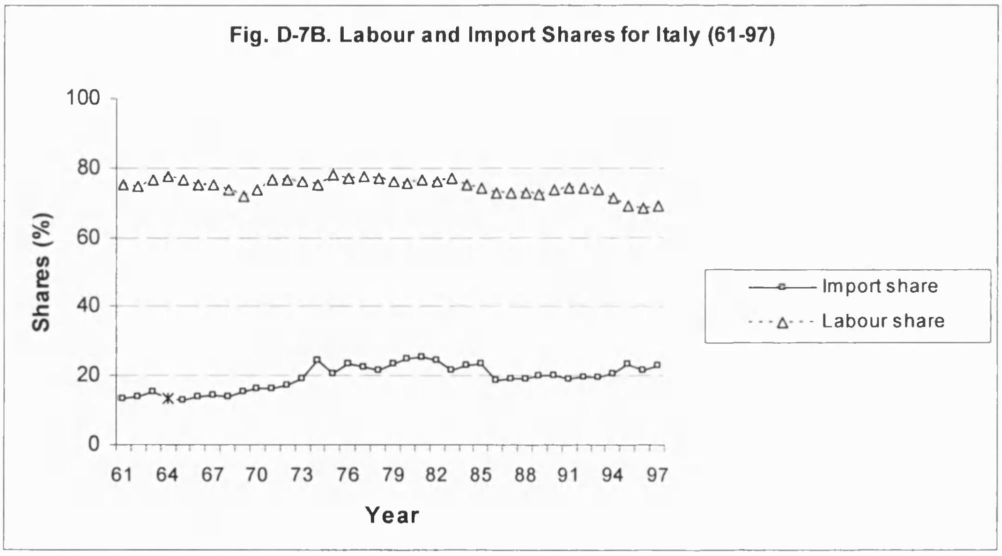


Fig. D-7B. Labour and Import Shares for Italy (61-97)
Shares (%)
Year
Import share
Labour share

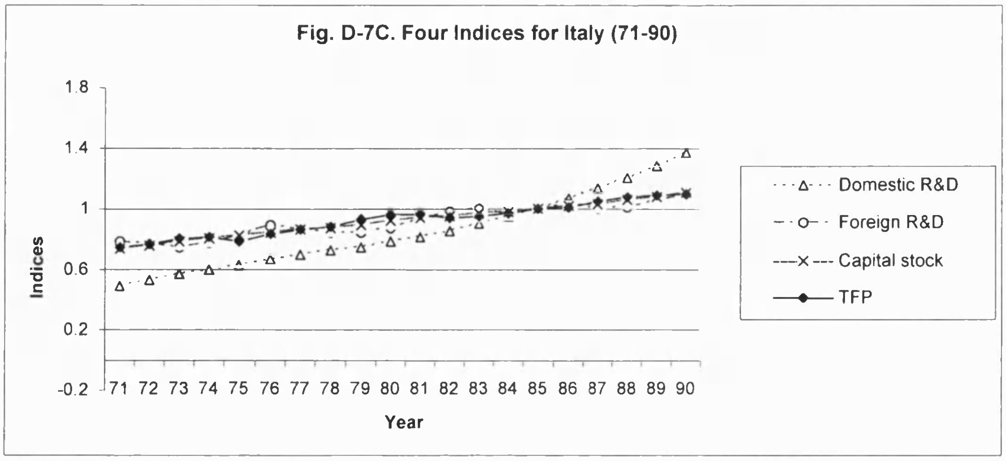


Fig. D-7C. Four Indices for Italy (71-90)
Indices
Year
Domestic R&D
Foreign R&D
Capital stock
TFP

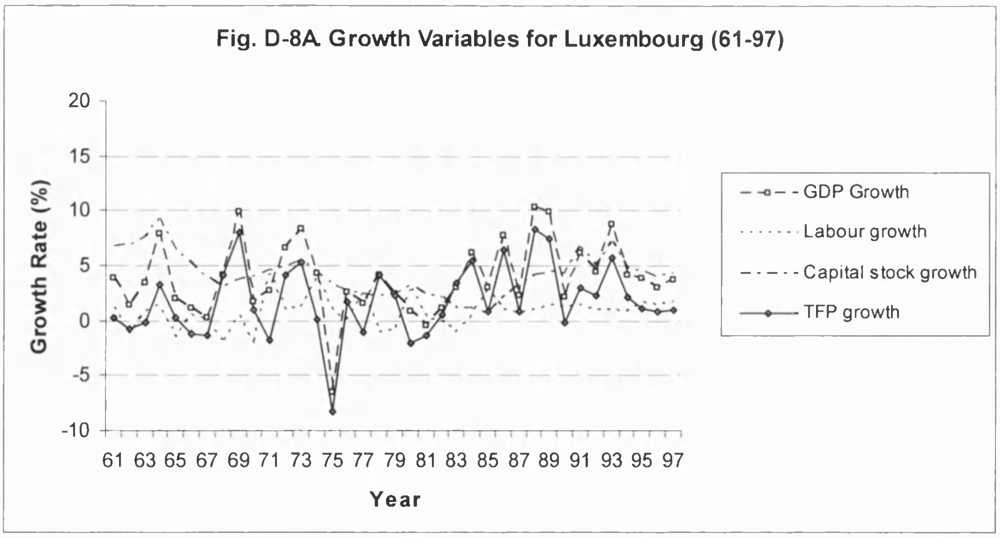


Fig. D-8A. Growth Variables for Luxembourg (61-97)
Growth Rate (%)
20
15
10
5
0
-5
-10
61 63 65 67 69 71 73 75 77 79 81 83 85 87 89 91 93 95 97
Year
GDP Growth
Labour growth
Capital stock growth
TFP growth

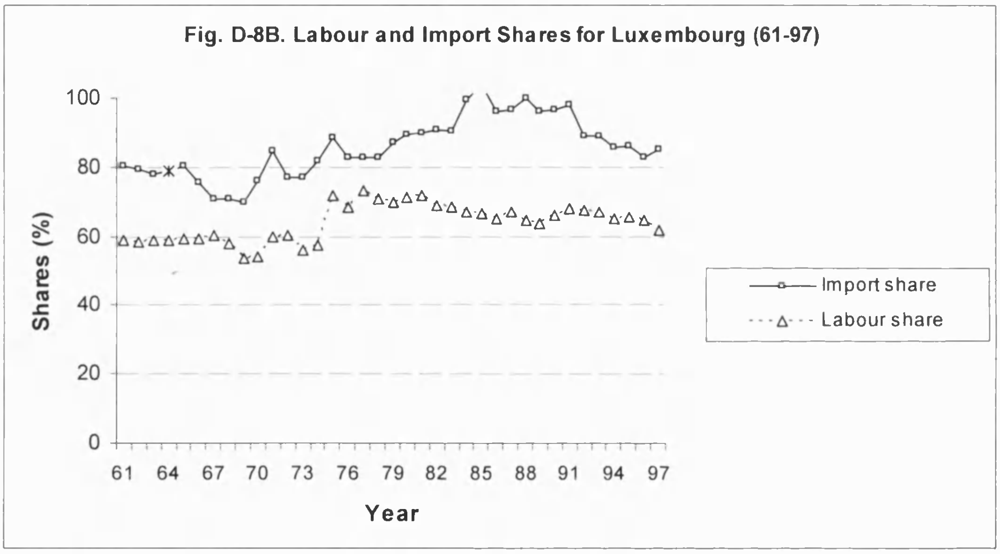


Fig. D-8B. Labour and Import Shares for Luxembourg (61-97)
Shares (%)
100
80
60
40
20
0
61 64 67 70 73 76 79 82 85 88 91 94 97
Year
Import share
Labour share

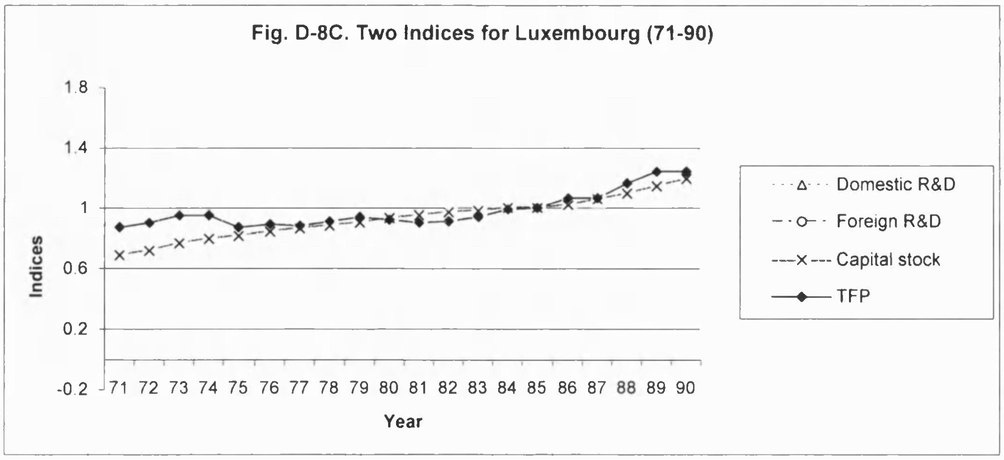


Fig. D-8C. Two Indices for Luxembourg (71-90)
Indices
1.8
1.4
1
0.6
0.2
-0.2
71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90
Year
Domestic R&D
Foreign R&D
Capital stock
TFP

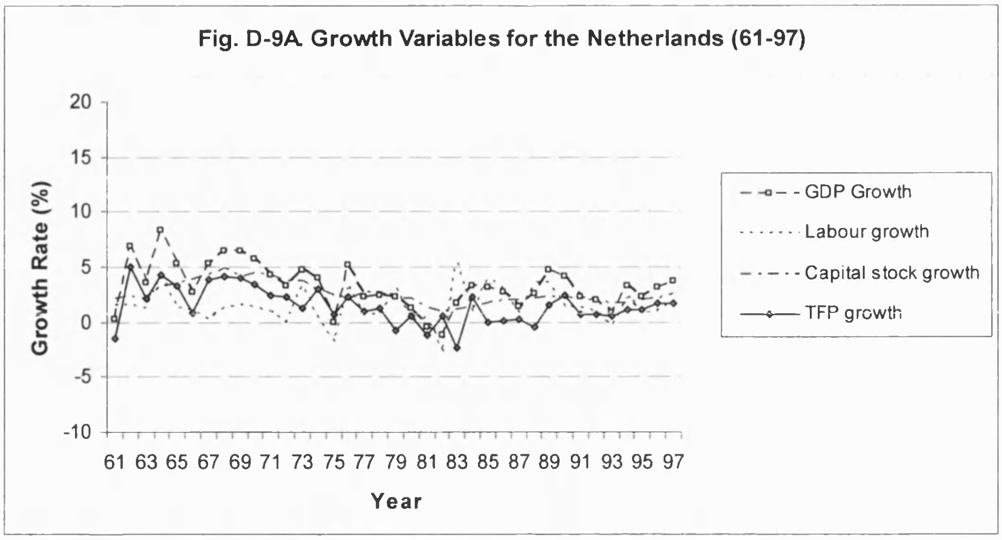


Fig. D-9A. Growth Variables for the Netherlands (61-97)
Growth Rate (%)
20
15
10
5
0
-5
-10
61 63 65 67 69 71 73 75 77 79 81 83 85 87 89 91 93 95 97
Year
GDP Growth
Labour growth
Capital stock growth
TFP growth

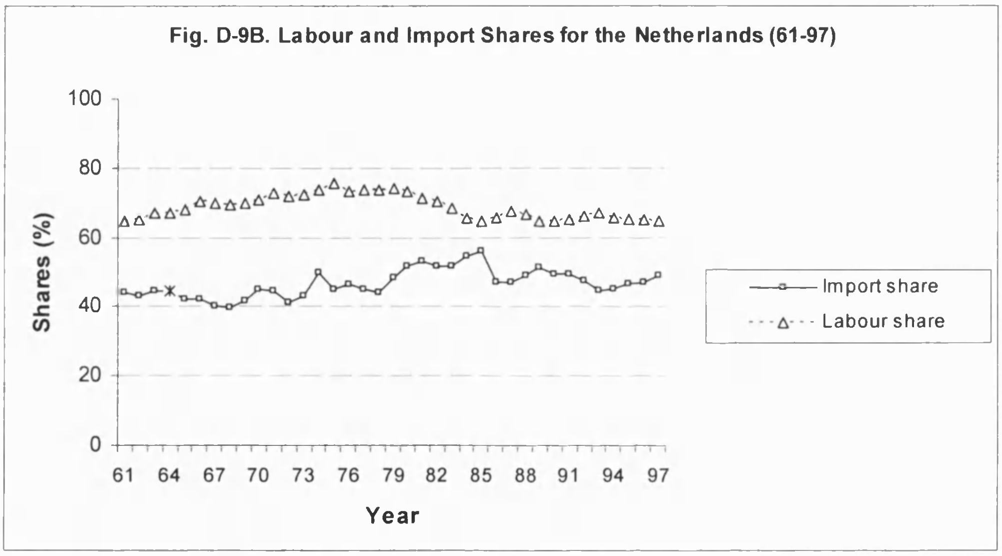


Fig. D-9B. Labour and Import Shares for the Netherlands (61-97)
Shares (%)
100
80
60
40
20
0
61 64 67 70 73 76 79 82 85 88 91 94 97
Year
Import share
Labour share

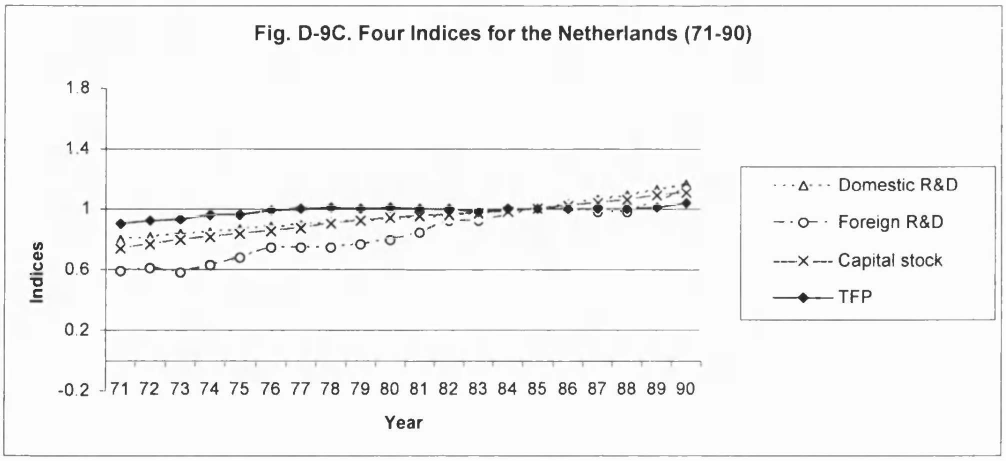


Fig. D-9C. Four Indices for the Netherlands (71-90)
Indices
1.8
1.4
1
0.6
0.2
-0.2
71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90
Year
Domestic R&D
Foreign R&D
Capital stock
TFP

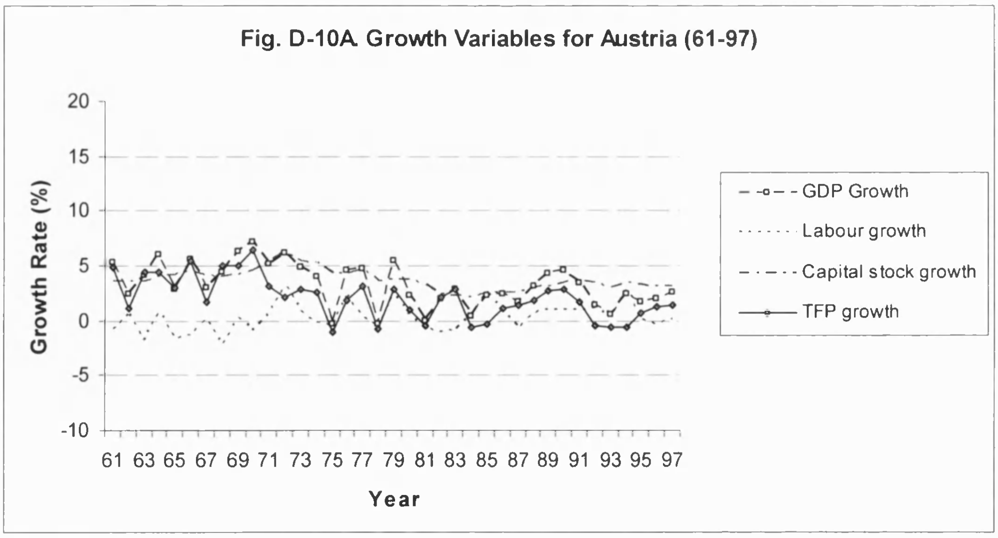


Fig. D-10A. Growth Variables for Austria (61-97)
Growth Rate (%)
20
15
10
5
0
-5
-10
61 63 65 67 69 71 73 75 77 79 81 83 85 87 89 91 93 95 97
Year
GDP Growth
Labour growth
Capital stock growth
TFP growth

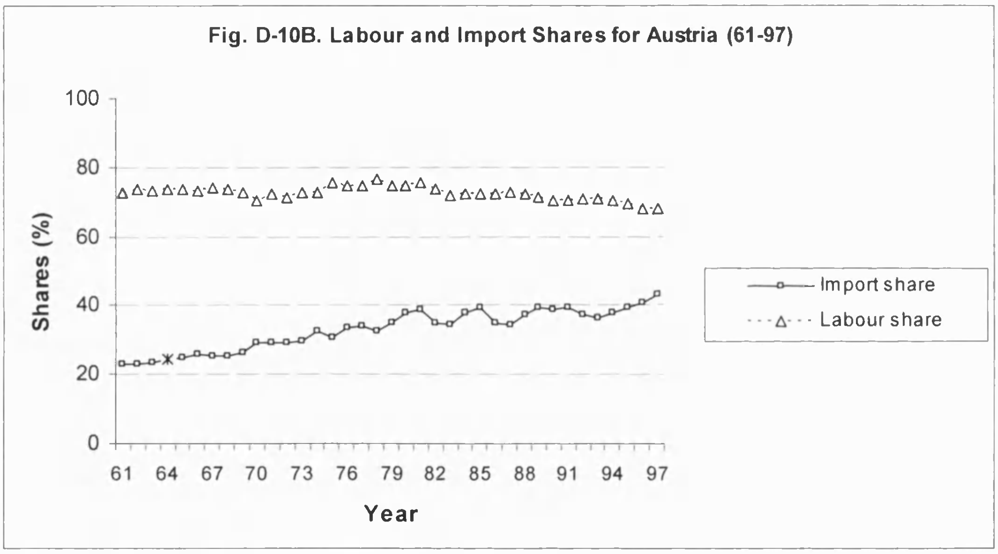


Fig. D-10B. Labour and Import Shares for Austria (61-97)
Shares (%)
100
80
60
40
20
0
61 64 67 70 73 76 79 82 85 88 91 94 97
Year
Import share
Labour share

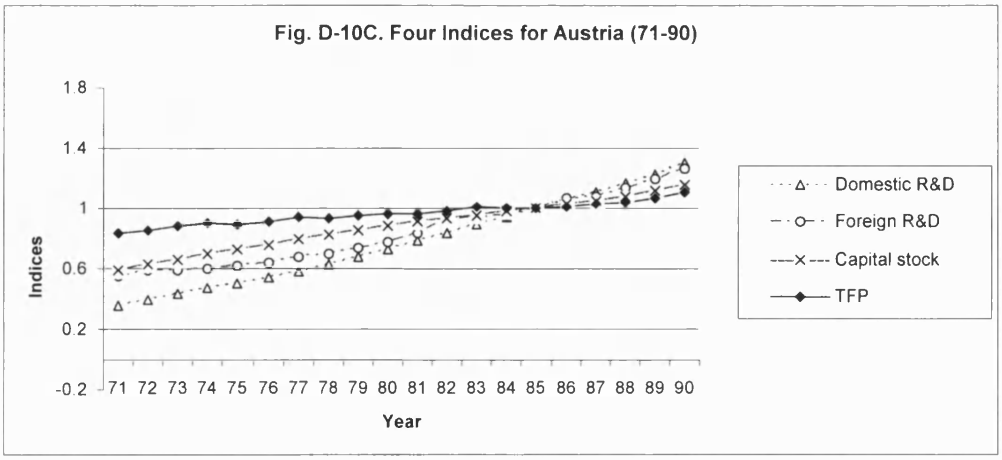


Fig. D-10C. Four Indices for Austria (71-90)
Indices
1.8
1.4
1
0.6
0.2
-0.2
71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90
Year
Domestic R&D
Foreign R&D
Capital stock
TFP

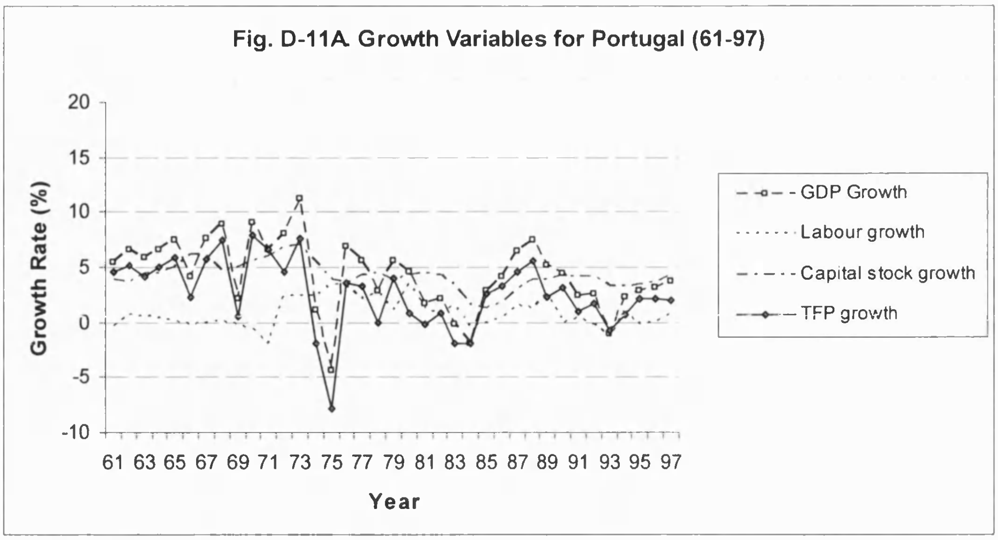


Fig. D-11A. Growth Variables for Portugal (61-97)
Growth Rate (%)
Year
GDP Growth
Labour growth
Capital stock growth
TFP growth

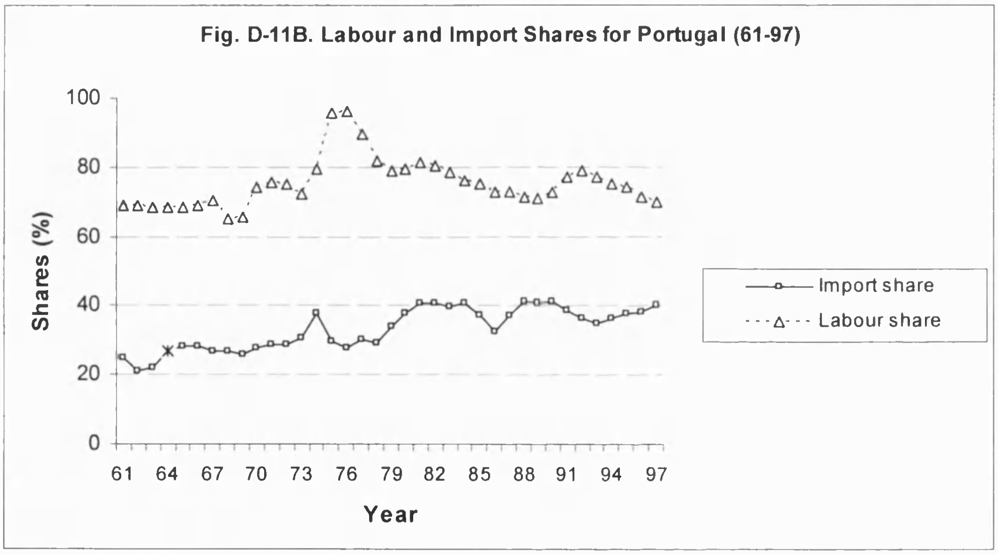


Fig. D-11B. Labour and Import Shares for Portugal (61-97)
Shares (%)
Year
Import share
Labour share

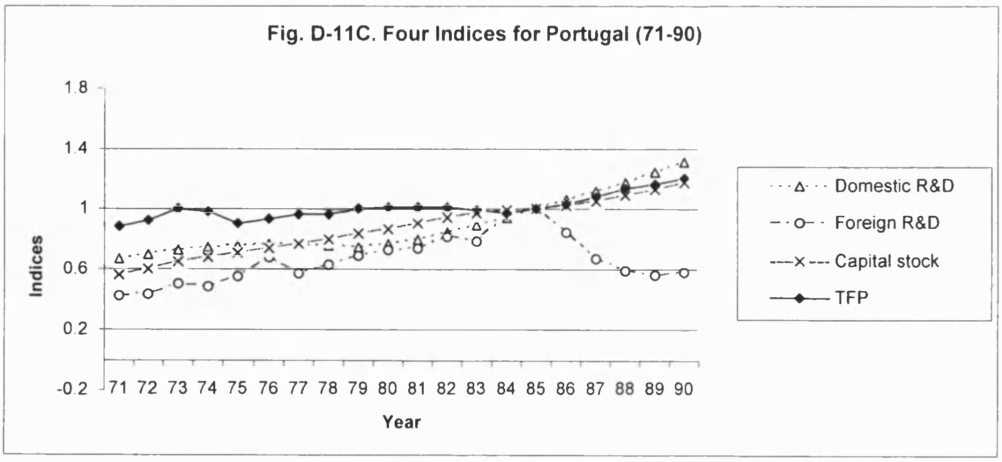


Fig. D-11C. Four Indices for Portugal (71-90)
Indices
Year
Domestic R&D
Foreign R&D
Capital stock
TFP

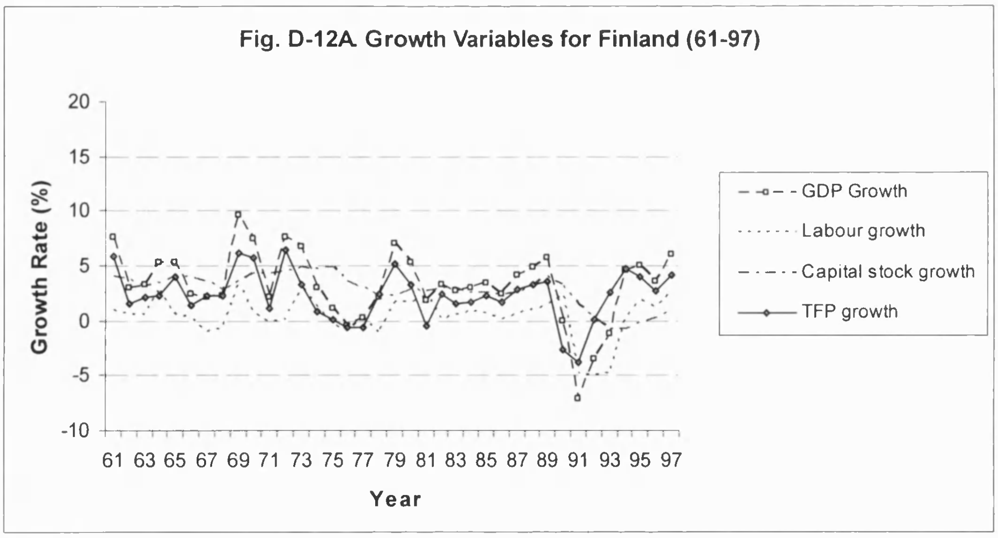


Fig. D-12A. Growth Variables for Finland (61-97)
Growth Rate (%)
20
15
10
5
0
-5
-10
61 63 65 67 69 71 73 75 77 79 81 83 85 87 89 91 93 95 97
Year
GDP Growth
Labour growth
Capital stock growth
TFP growth

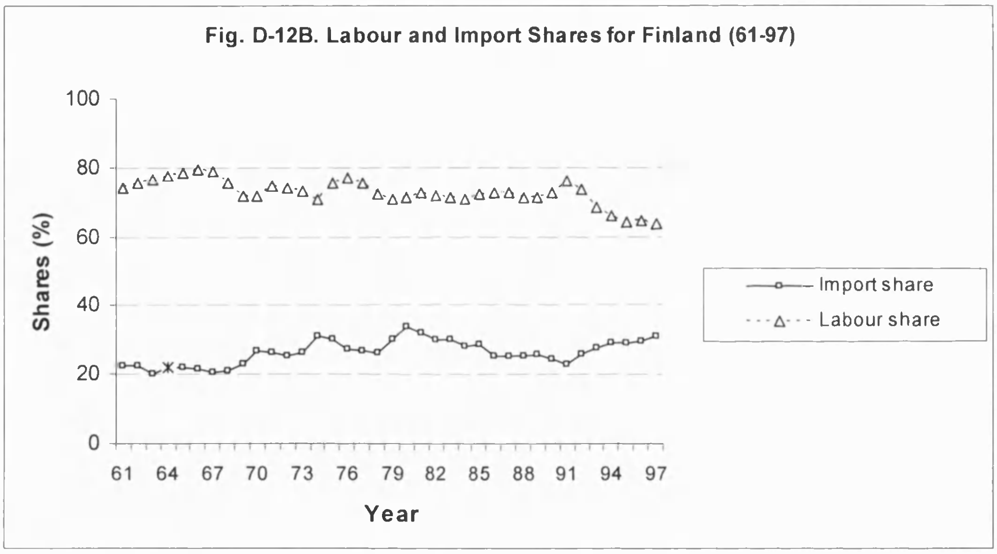


Fig. D-12B. Labour and Import Shares for Finland (61-97)
Shares (%)
100
80
60
40
20
0
61 64 67 70 73 76 79 82 85 88 91 94 97
Year
Import share
Labour share

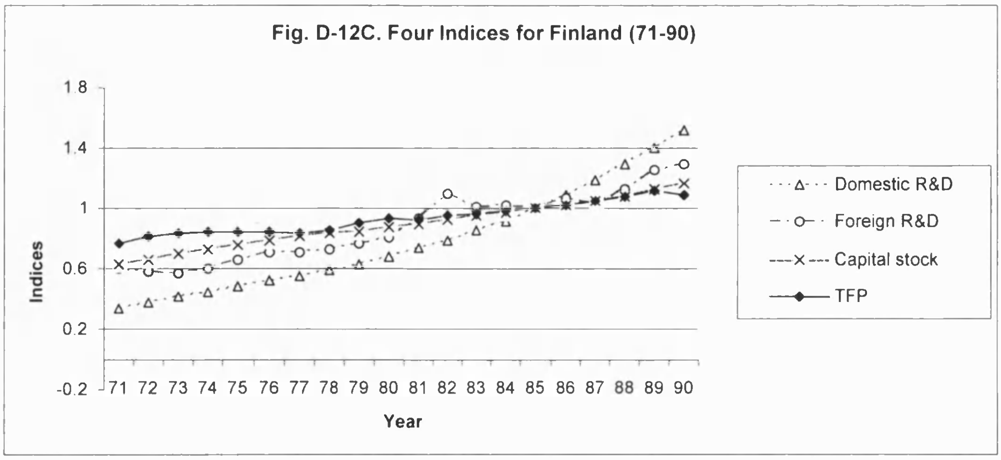


Fig. D-12C. Four Indices for Finland (71-90)
Indices
1.8
1.4
1
0.6
0.2
-0.2
71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90
Year
Domestic R&D
Foreign R&D
Capital stock
TFP

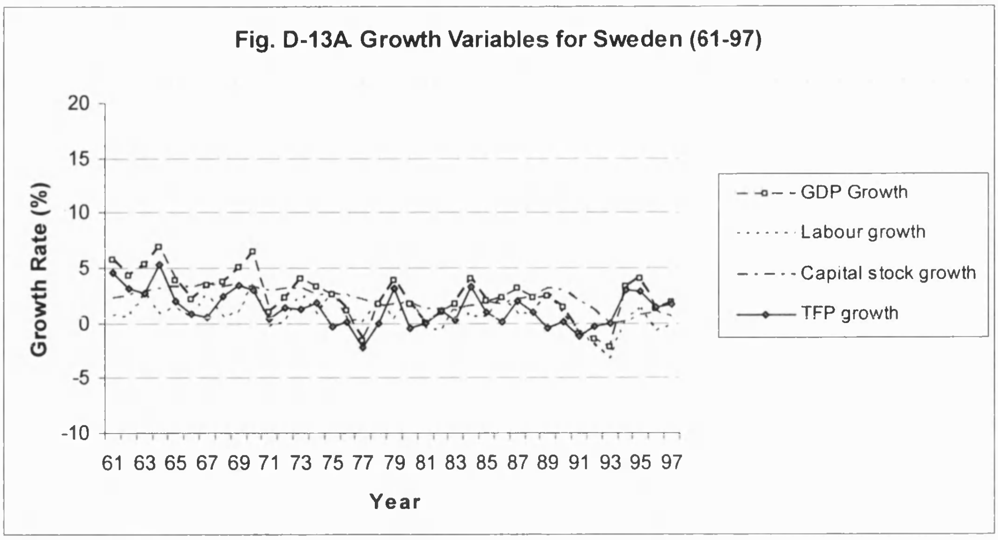


Fig. D-13A. Growth Variables for Sweden (61-97)
Growth Rate (%)
20
15
10
5
0
-5
-10
61 63 65 67 69 71 73 75 77 79 81 83 85 87 89 91 93 95 97
Year
GDP Growth
Labour growth
Capital stock growth
TFP growth

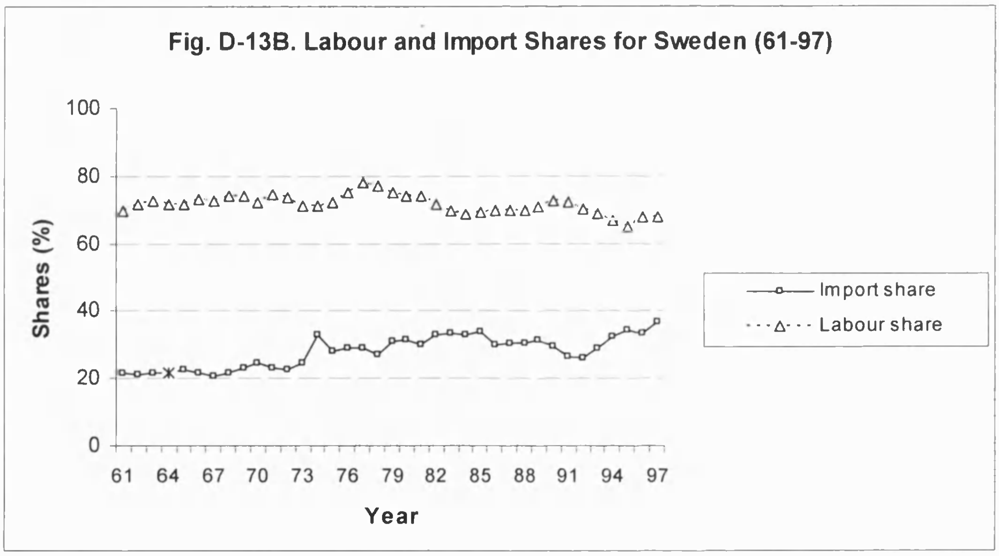


Fig. D-13B. Labour and Import Shares for Sweden (61-97)
Shares (%)
100
80
60
40
20
0
61 64 67 70 73 76 79 82 85 88 91 94 97
Year
Import share
Labour share

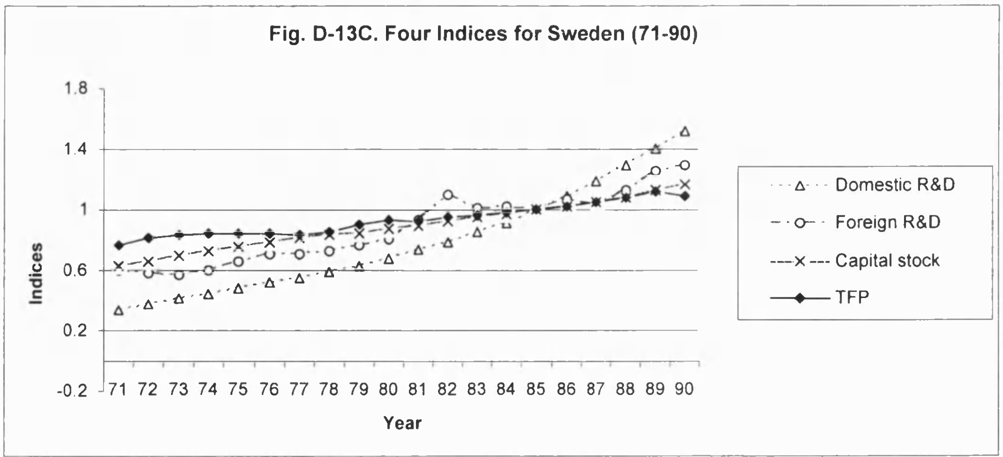


Fig. D-13C. Four Indices for Sweden (71-90)
Indices
1.8
1.4
1
0.6
0.2
-0.2
71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90
Year
Domestic R&D
Foreign R&D
Capital stock
TFP

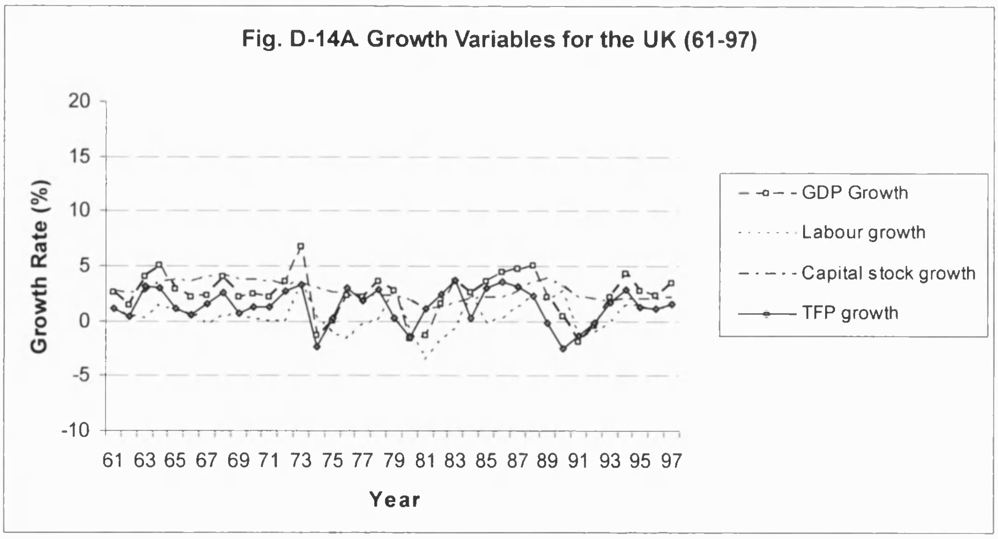


Fig. D-14A. Growth Variables for the UK (61-97)
Growth Rate (%)
Year
GDP Growth
Labour growth
Capital stock growth
TFP growth

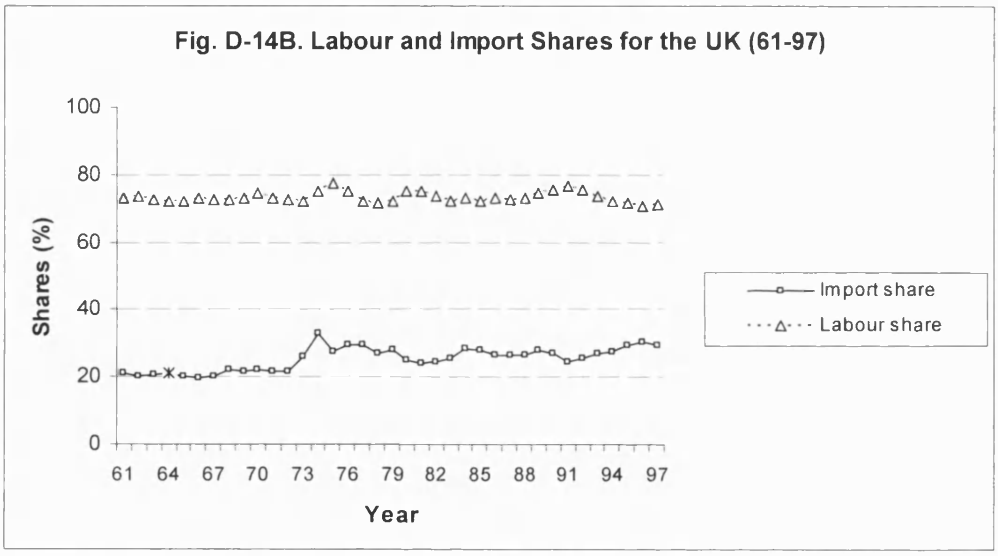


Fig. D-14B. Labour and Import Shares for the UK (61-97)
Shares (%)
Year
Import share
Labour share

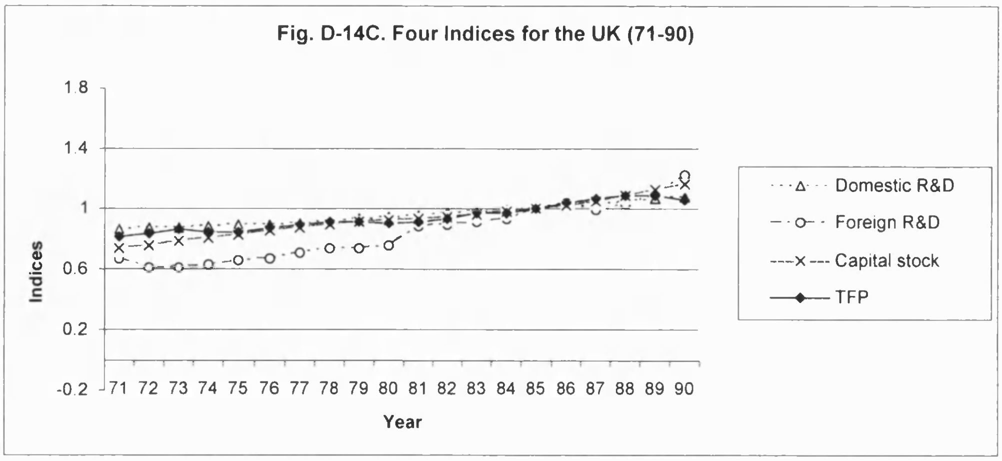


Fig. D-14C. Four Indices for the UK (71-90)
Indices
Year
Domestic R&D
Foreign R&D
Capital stock
TFP

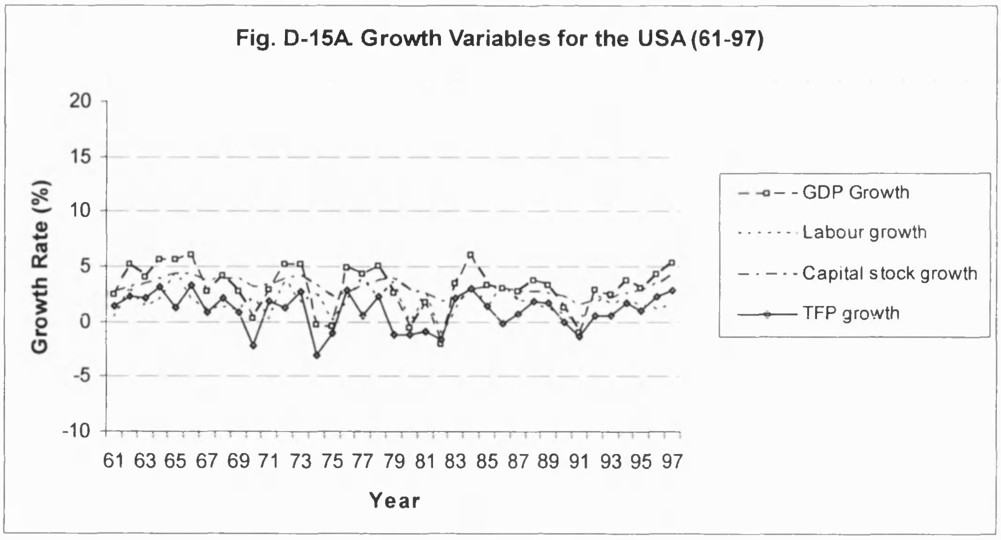


Fig. D-15A. Growth Variables for the USA (61-97)

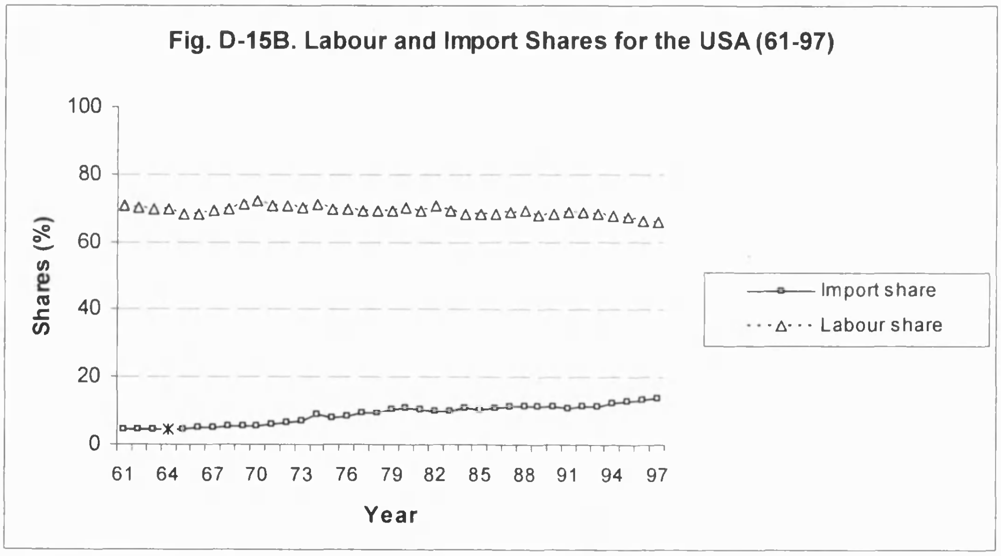


Fig. D-15B. Labour and Import Shares for the USA (61-97)

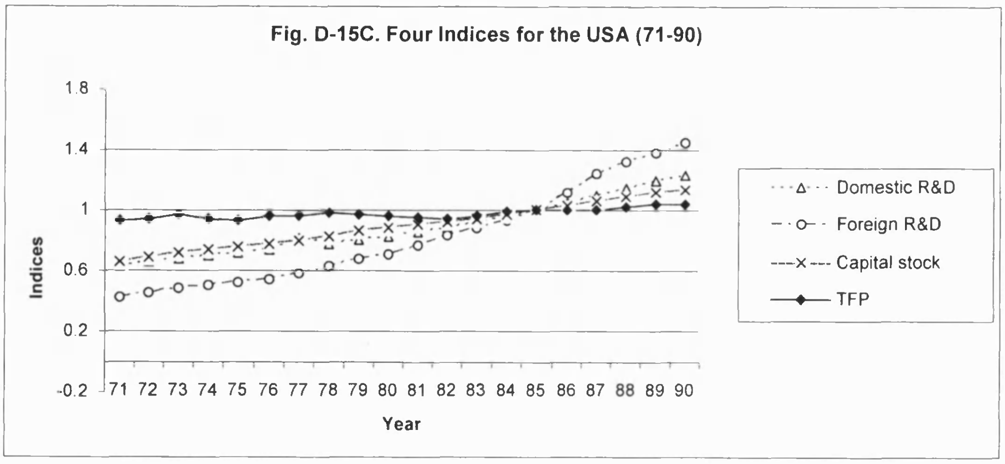


Fig. D-15C. Four Indices for the USA (71-90)

Fig. D-16A. Growth Variables for Japan (61-97)

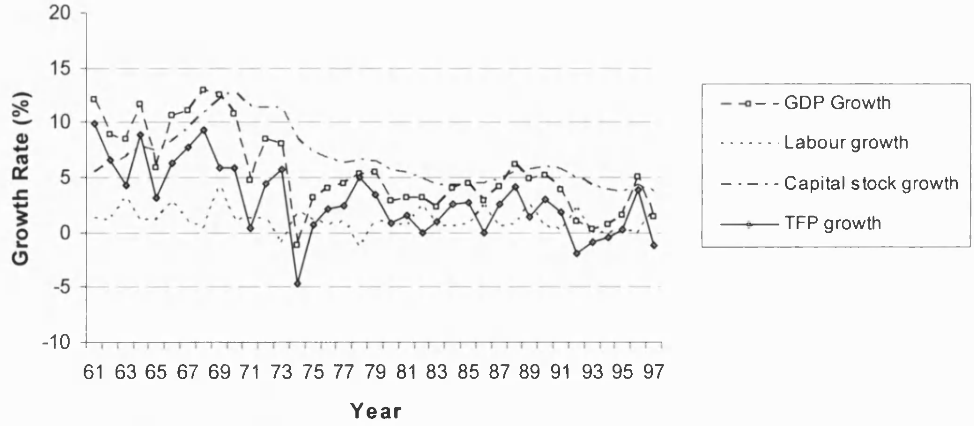


Fig. D-16B. Labour and Import Shares for Japan (61-97)

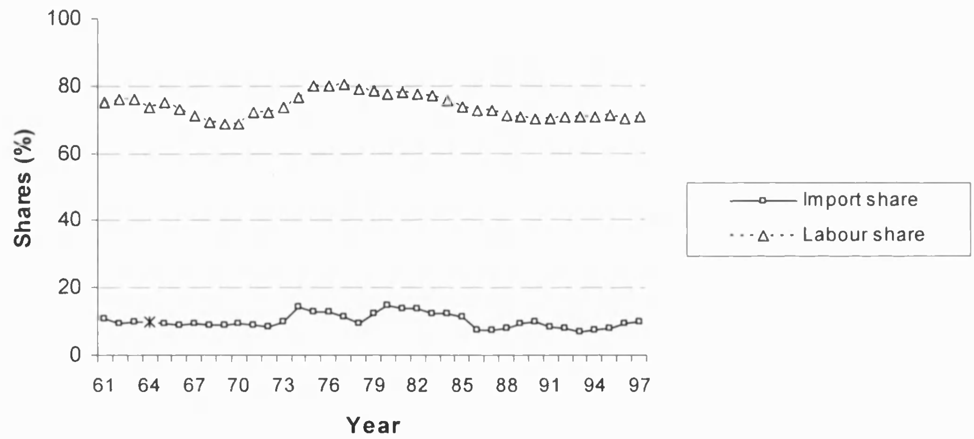
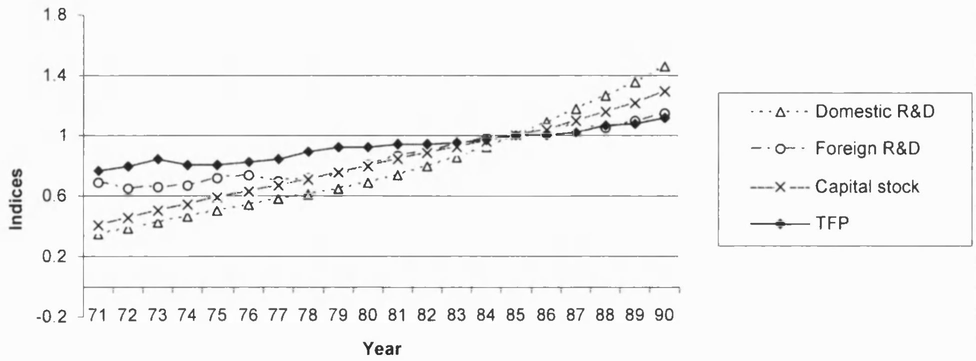


Fig. D-16C. Four Indices for Japan (71-90)



APPENDIX E

DATA SOURCES AND DEFINITIONS FOR CHAPTER 4

The data in chapter four are respectively from chapter three, World Bank (2000), and Barro and Lee (2001).

Per capita GDP growth rates, per capita capital stock growth rates, TFP growth rates, and capital stock figures are taken from chapter three. For details, see chapter three and appendix B.

Per capita real GDP at purchasing power parity (PPP), the inflation rate, investment rate, general government consumption ratio, openness, fertility rate, life expectancy and urbanisation are taken from World Bank (2000). Per capita GDP at PPP is constructed from per capita GDP growth rates in constant prices and 1995 GDP at PPP. GDP at PPP is gross domestic product converted to international dollars using purchasing power parity rates. The inflation rate is the consumer price index reflecting the annual percentage change in the cost to the average consumer of acquiring a fixed basket of goods and services that may be fixed or changed at specified intervals, for example annually. The investment rate is gross domestic investment as a percentage of GDP. The gross domestic investment consists of outlays on additions to the fixed assets of the economy, plus net changes in the level of inventories. The general government consumption ratio is general government consumption as a percentage of GDP. General government consumption includes all current spending on purchases of goods and services (including wages and salaries). Openness is measured by three alternative terms: imports, exports, and total trade in goods and services as a percentage of GDP. Imports of goods and services represent the value of all goods and other market services provided to or received from the rest of the world. Exports of goods and services represent the value of all goods and other market services provided to or received from the rest of the world. The fertility rate in total represents the number of children that would be born to a woman if she were to live to the end of her childbearing years and bear children in accordance with prevailing age-specific fertility rates. Life expectancy is life expectancy at birth, which indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life. Urbanisation is measured as urban population as a percentage of total population for each country. Urban population is the midyear population of areas defined as urban in each country and reported to the United Nations. For more details, see World Bank (2000).

Educational attainments are taken from Barro and Lee (2001). The measures of educational attainment are based on years of schooling without adjustment for variations in school quality, which are provided and updated by Barro and Lee (2001; 1996; 1993). The figures were constructed at five-year intervals from 1960 to 1995, following previous studies (Barro and Lee 1993; 1996). The data set contains estimates of educational attainment for the population by age – over 15 and over 25. For each category, four levels of educational attainment are estimated: no schooling, primary, secondary, and higher education. For each level of education, two estimates - education attained and education completed - are provided separately. The data are generally constructed for the whole population as well as for male and female populations. In addition, the average number of years of schooling achieved by the average person in each country is also estimated. For more details, see Barro and Lee (2001, 1996, 1993).

APPENDIX F

DESCRIPTIVE STATISTICS OF THE DATA FOR CHPATER 4

Variable Description	Sample size	Descriptive statistics					
		Mean	S. D.	Skewness	Kurtosis	Min	Max
Ln (GDP per capita)	592	9.641	0.520	-0.695	3.281	7.891	10.681
Ln (capital stocks per capita)	592	13.122	2.157	0.168	2.722	8.592	18.114
Inflation rate	592	6.721	5.380	1.528	5.256	-0.708	29.300
Investment rate	592	23.466	4.890	0.503	2.979	13.300	40.800
Government consumption rate	592	16.039	4.710	0.581	3.281	7.320	29.600
Total trade/GDP	592	63.618	40.905	1.392	4.731	9.430	210.000
Imports/GDP	592	32.071	19.776	1.324	4.644	4.290	104.000
Exports/GDP	592	31.545	21.365	1.440	4.817	5.040	106.000
Ln (life expectancy)	592	4.298	0.037	-0.456	3.313	4.156	4.387
Fertility rate	592	2.042	0.575	1.101	4.005	1.150	4.070
Urbanisation	592	70.660	15.842	-0.719	3.498	22.500	97.100
Secondary education attained over age 15	120	37.303	15.760	-0.357	2.422	2.100	67.800
Secondary education completed over age 15	120	14.180	9.850	1.167	4.436	0.100	49.300
Higher education attained over age 15	120	9.832	7.517	1.852	8.353	1.000	44.200
Higher education completed over age 15	120	4.448	3.858	1.921	8.781	0.200	22.500
Average years of schooling	120	7.382	1.949	-0.361	3.312	1.860	11.890

Note. S.D. is Standard Deviation.

APPENDIX G

GRAPHICAL DESCRIPTION OF SOME VARIABLES FOR CHAPTER 4

In the following figures, the solid line is the average of the individual observations for the 16 OECD countries.

Fig. G-1A. Ln (GDP per capita)

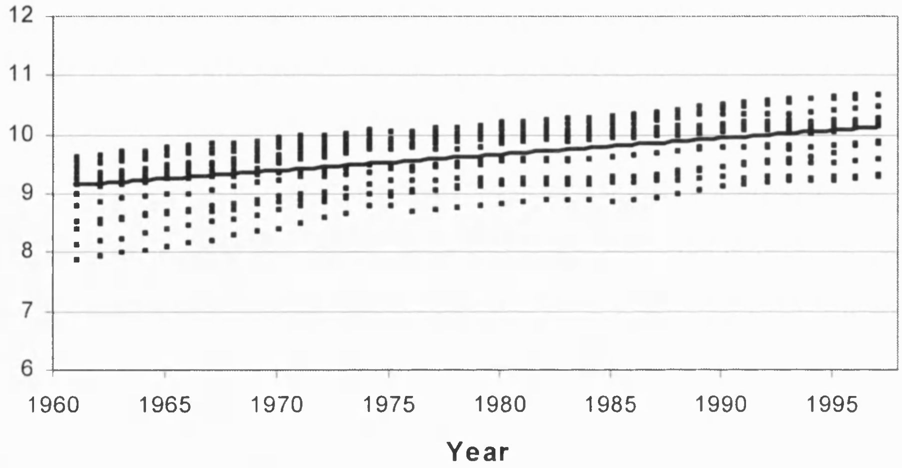


Fig. G-1B. Ln (Capital stock per capita)

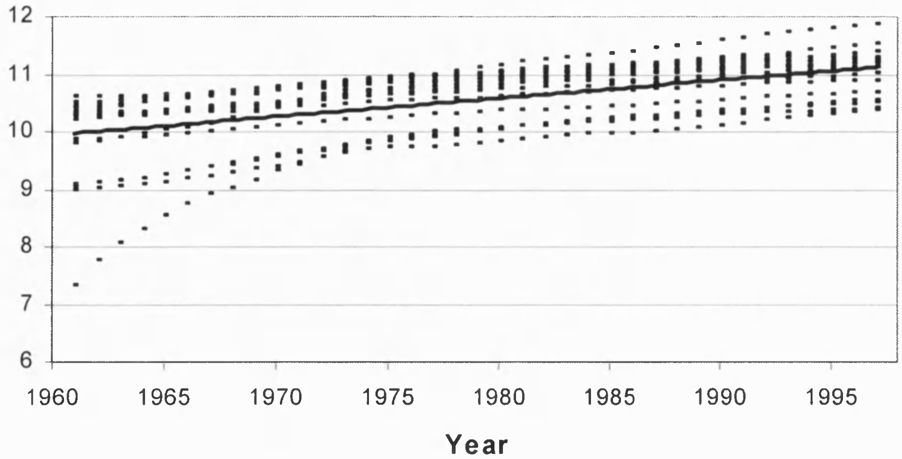


Fig. G-2A. Inflation rate

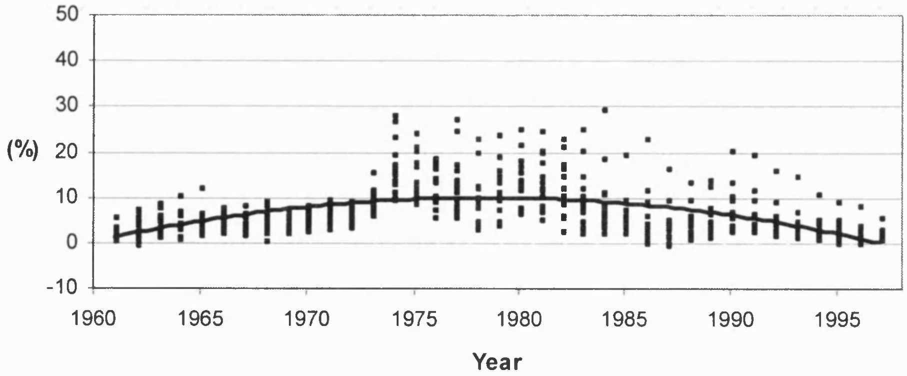


Fig. G-2B. Investment rate

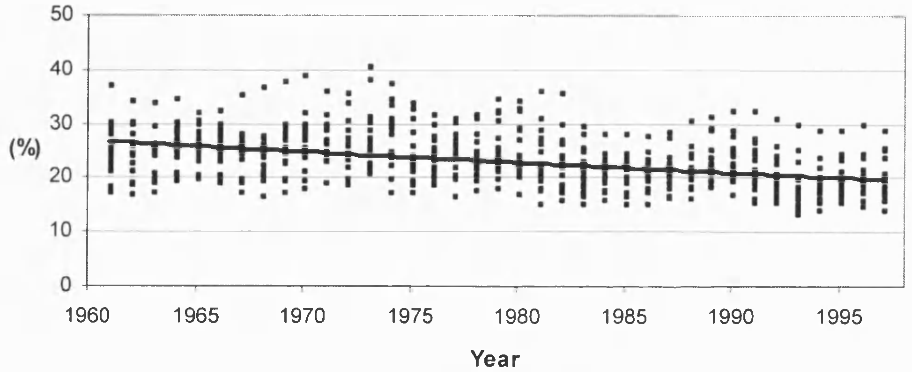


Fig. G-2C. Government consumption rate

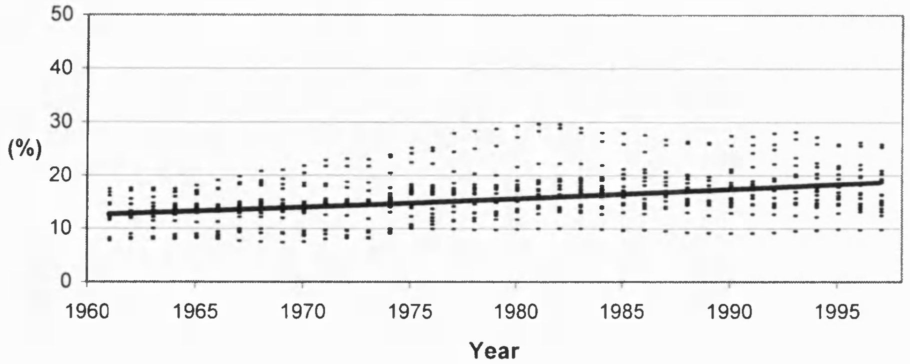


Fig. G-2D. Fertility rate

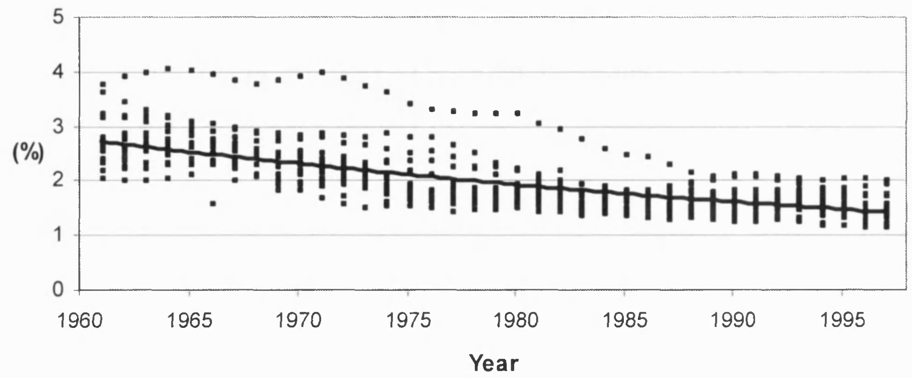


Fig. G-2F. Urbanisation

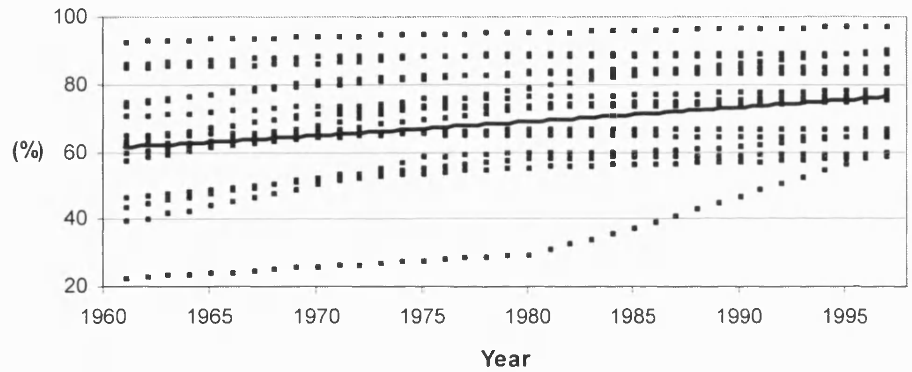


Fig. G-3. Ln (life expectancy)

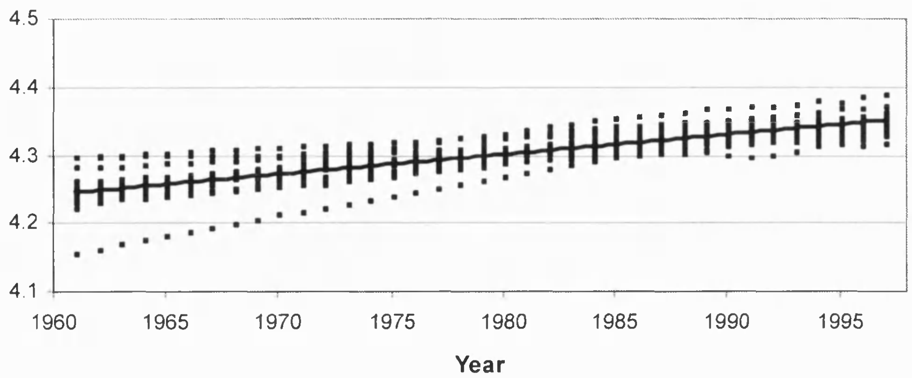


Fig. G-4A. Openness (total trade / GDP)

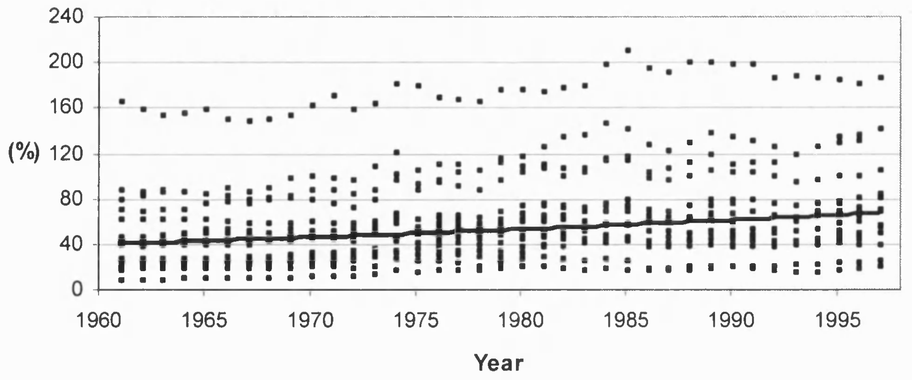


Fig. G-4B. Openness (export / GDP)

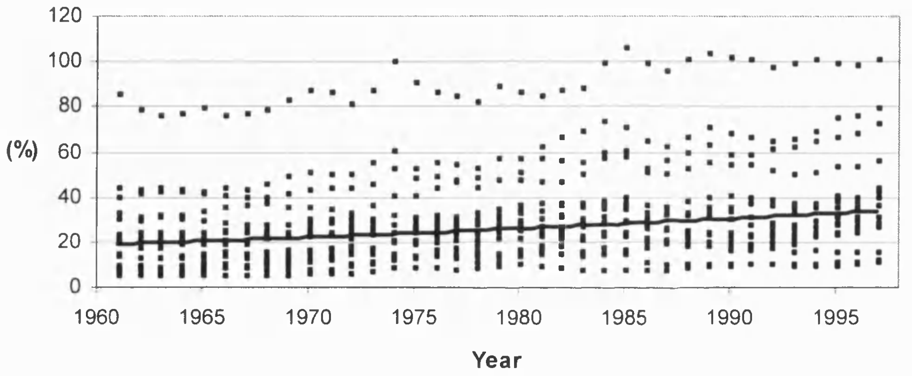
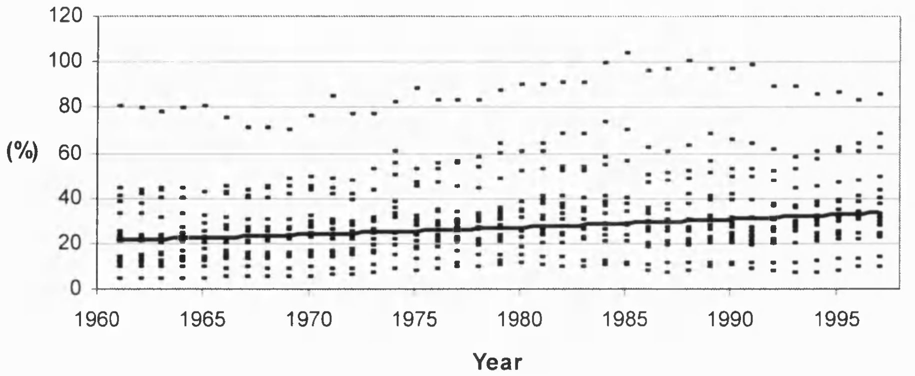


Fig. G-4C. Openness (import / GDP)



APPENDIX H

NOTES ON TRANSITION INDICATORS

The transition indicator scores in chapter five are provided by the European Bank for Reconstruction and Development (EBRD). They reflect the judgment of the EBRD about country-specific progress in transition. The scores are based on the following classification system, which was originally developed in the 1994 Transition Report, but has been refined and amended in subsequent Reports. EBRD transition indicators are recorded by the integers 1 to 4, with pluses and minuses, valued for aggregation at 0.3, indicating slightly better or worse achievements.

PRICE LIBERALISATION

1	Most prices formally controlled by the government.
2	Some lifting of price administration; state procurement at non-market prices for the majority of product categories.
3	Significant progress on price liberalisation, but state procurement at non-market prices remains substantial.
4	Comprehensive price liberalisation; state procurement at non-market prices largely phased out; only a small number of administered prices remain.
4+	Standards and performance typical of advanced industrial economies: complete price liberalisation with no price control outside housing, transport and natural monopolies.

TRADE AND FOREIGN EXCHANGE SYSTEM (TRADE LIBERALISATION)

1	Widespread import and/or export controls or very limited legitimate access to foreign exchange.

2	Some liberalisation of import and/or export controls; almost full current account convertibility in principle but with a foreign exchange regime that is not fully transparent.
3	Removal of almost all quantities and administrative import and export restrictions; almost full current account convertibility.
4	Removal of all quantities and administrative import and export restrictions (apart from agriculture) and all significant export tariffs; insignificant direct involvement in exports and imports by ministries and state-owned trading companies; no major non-uniformity of customs duties for non-agricultural goods and services; full current account convertibility.
4+	Standards and performance norms of advanced industrial economies: removal of most tariff barriers; membership in WTO.

LARGE-SCALE PRIVATISATION

1	Little private ownership.
2	Comprehensive scheme almost ready for implementation; some sales completed.
3	More than 25 percent of large-scale enterprise assets in private hands or in the process of being privatised, but possibly with major unresolved issues regarding corporate governance.
4	More than 50 percent of state-owned enterprise and farm assets in private ownership and significant progress on corporate governance of these enterprises.
4+	Standards and performance typical of advanced industrial economies: more than 75 percent of enterprise assets in private ownership with effective corporate governance.

SMALL-SCALE PRIVATISATION

1	Little progress.
2	Substantial share privatised.
3	Comprehensive programme almost ready for implementation.
4	Complete privatisation of small companies with tradable ownership rights.

4+	Standards and performance typical of advanced industrial economies: no state ownership of small enterprises; effective tradability of land.

GOVERNANCE AND ENTERPRISE RESTRUCTURING (ENTERPRISE REFORM)

1	Soft budget constraints (lax credit and subsidy policies weakening financial discipline at the enterprise level); few other reforms to promote corporate governance.
2	Moderately tight credit and subsidy policy, but weak enforcement of bankruptcy legislation and little action taken to strengthen competition and corporate governance.
3	Significant and substantial actions to harden budget constraints and to promote corporate governance effectively.
4	Substantial improvement in corporate governance and significant new investment at the enterprise level.
4+	Standards and performance typical of advanced industrial economies: effective corporate control exercised through domestic financial institutions and markets, fostering market-driven restructuring.

COMPETITION POLICY

1	No competition legislation and institutions
2	Competition policy legislation and institutions set up; some reduction of entry restrictions or enforcement action on dominant firms.
3	Some enforcement actions to reduce abuse of market power and to promote a competitive environment, including break-ups of dominant conglomerates; substantial reduction of entry restrictions.
4	Significant enforcement actions to reduce abuse of market power and to promote a competitive environment
4+	Standards and performance typical of advanced industrial economies: effective enforcement of competitive policy; unrestricted entry to most markets.

BANKING REFORM AND INTEREST RATE LIBERALISATION (BANKING REFORM)

1	Little progress beyond establishment of a two-tier system.
2	Competition liberalisation of interest rates and credit allocation; limited use of directed credit or interest rate ceilings.
3	Substantial progress in establishment of bank solvency and of a framework for prudential supervision and regulation; full interest rate liberalisation with little preferential access to cheap refinancing; significant lending to private enterprises and significant presence of private banks.
4	Significant movement of banking laws and regulations towards BIS standards; well functioning banking competition and effective prudential supervision; significant term lending to private enterprises; substantial financial deepening
4+	Standards and performance norms of advanced industrial economies: full convergence of banking laws and regulations with BIS standards; provision of full set of competitive banking services.

SECURITY MARKETS AND NON-BANKING FINANCIAL INSTITUTIONS (NON-BANKING REFORM)

1	Little progress.
2	Formation of security exchange, market-makers and brokers; some trading in government paper and/or securities; rudimentary legal and regulatory framework for the issuance and trading of securities.
3	Substantial issuance of securities by private enterprises; establishment of independent share registries, secure clearance and settlement procedures, and some protection of minority shareholders; emergence of non-bank financial institutions (e.g. investment funds, private insurance and pension funds, leasing companies) and associated regulatory framework.
4	Securities laws and regulations approaching IOCSCO standards; substantial market liquidity and capitalisation; well-functioning non-bank financial institutions and effective regulation.
4+	Standards and performance norms of advanced industrial economies: full convergence of securities laws and regulations with IOSCO standards; fully developed non-bank intermediation.

APPENDIX I

DESCRIPTIVE STATISTICS OF THE DATA FOR CHAPTER 5

Code	Variable Description	Descriptive statistics					
		Mean	S.D.	Skewness	Kurtosis	Min	Max
R	Per capita GDP growth	-0.012	0.097	-1.746	7.837	-0.526	0.176
X_1	Logarithmic real GDP per capita (1995 US dollars)	8.274	0.674	-0.534	2.359	6.703	9.407
X_2	Investment share in GDP	23.063	8.443	0.736	5.156	1.600	59.770
X_3	Logarithmic inflation rate	1.630	0.873	0.380	2.975	-0.980	4.190
Z_1	EBRD index of price liberalisation	2.780	0.542	-2.106	6.548	1.000	3.300
r^{Z_1}	Change rate of above index	0.083	0.304	3.976	20.323	-0.330	2.000
Z_2	EBRD index of trade liberalisation	3.186	1.164	-0.843	2.207	1.000	4.300
r^{Z_2}	Change rate of above index	0.138	0.390	3.776	21.438	-0.500	3.000
Z_3	EBRD index of small-scale privatisation	3.206	1.024	-0.752	2.391	1.000	4.300
r^{Z_3}	Change rate of above index	0.139	0.285	2.555	9.546	0.000	1.700
Z_4	EBRD index of large-scale privatisation	2.459	0.912	-0.148	2.111	1.000	4.000
r^{Z_4}	Change rate of above index	0.146	0.310	1.931	5.481	-0.410	1.000
Z_5	EBRD index of enterprise reform	2.012	0.717	-0.021	1.923	1.000	3.300
r^{Z_5}	Change rate of above index	0.105	0.288	2.330	7.312	-0.410	1.000
Z_6	EBRD index of competition policy	1.907	0.632	-0.037	2.257	1.000	3.000
r^{Z_6}	Change rate of above index	0.090	0.264	3.003	10.671	0.000	1.300
Z_7	EBRD index of banking sector reform	2.159	0.822	-0.064	1.968	1.000	4.000
r^{Z_7}	Change rate of above index	0.113	0.279	2.287	7.408	-0.500	1.000
Z_8	EBRD index of reform of non-banking financial institutions	1.824	0.686	0.380	2.473	1.000	3.700
r^{Z_8}	Change rate of above index	0.098	0.256	2.523	8.442	-0.430	1.000

Note. S.D. is Standard Deviation. Total observations are 225

APPENDIX J

GRAPHICAL DESCRIPTION OF SOME VARIABLES FOR CHAPTER 5

In the following figures, the solid line is the average of the individual observations for the 25 transition countries, dealt with by the EBRD, except for Bosnia-Hertzgovina and Serbia and Montenegro.

Fig. J-1. Annual per capita GDP growth

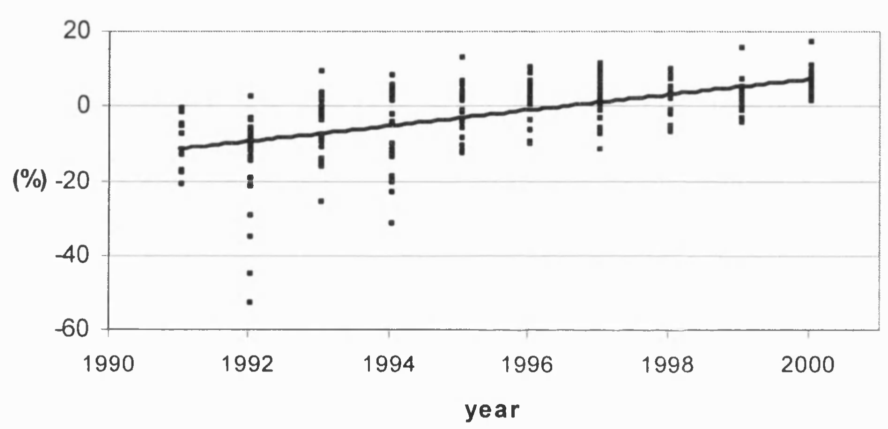
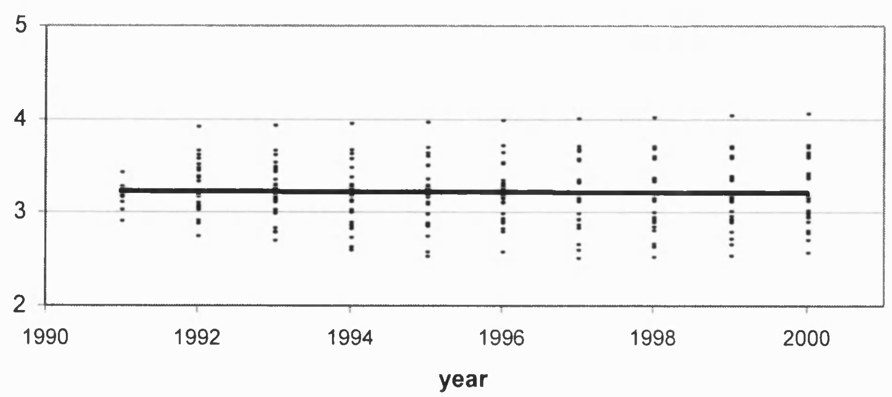


Fig. J-2. Ln (per capita GDP at 1995 constant prices)



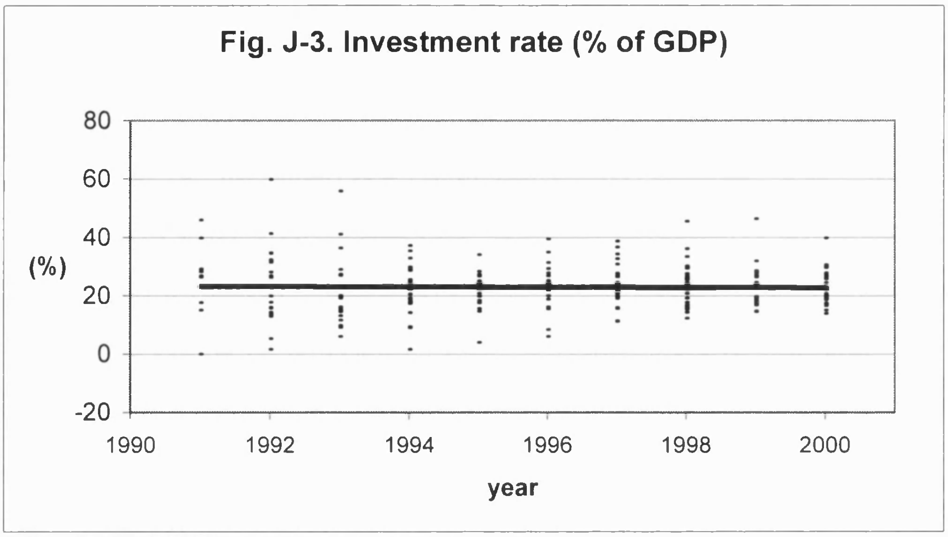


Fig. J-3. Investment rate (% of GDP)
80
60
40
(%)
20
0
-20
1990
1992
1994
1996
1998
2000
year

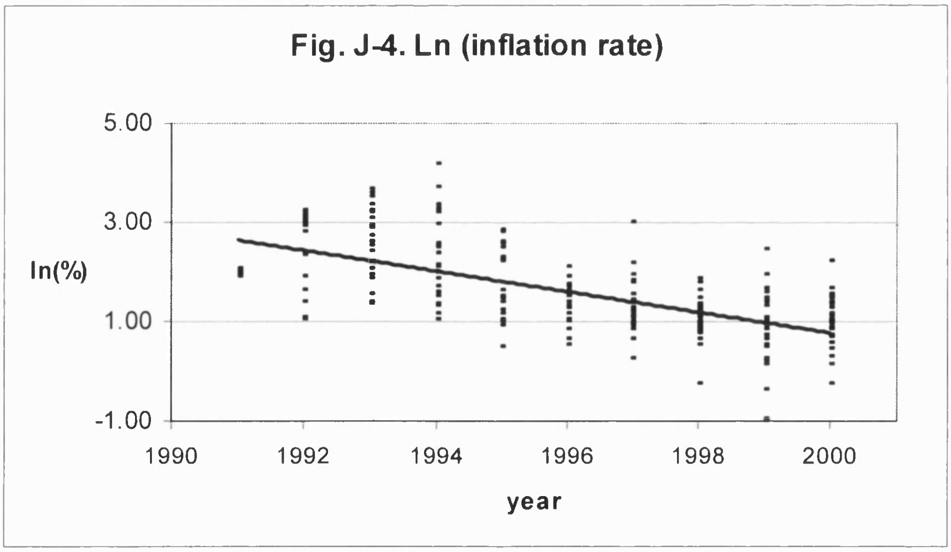


Fig. J-4. Ln (inflation rate)
5.00
3.00
ln(%)
1.00
-1.00
1990
1992
1994
1996
1998
2000
year

Fig. J-5A. Price liberalisation index

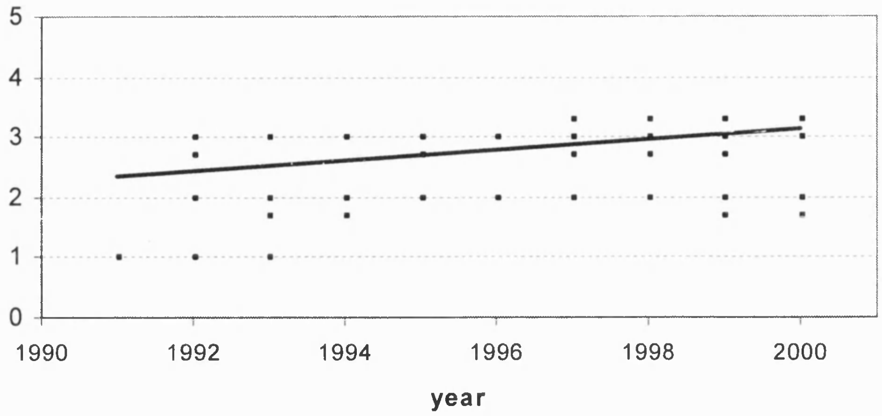


Fig. J-5B. Trade liberalisation index

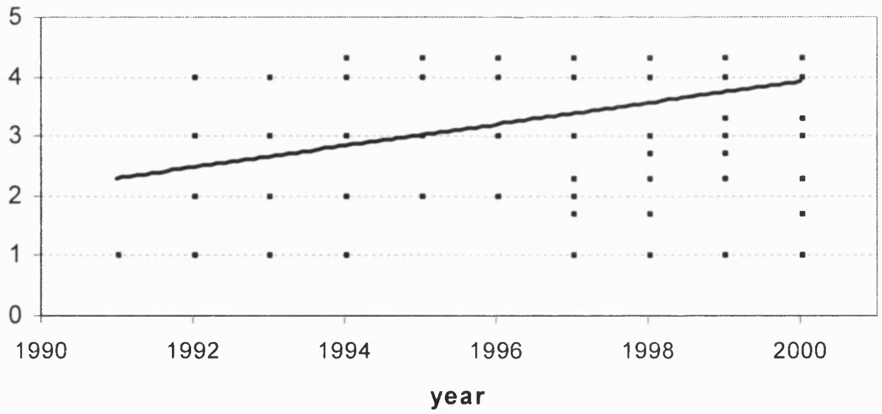


Fig. J-5C. Small-scale privatisation index

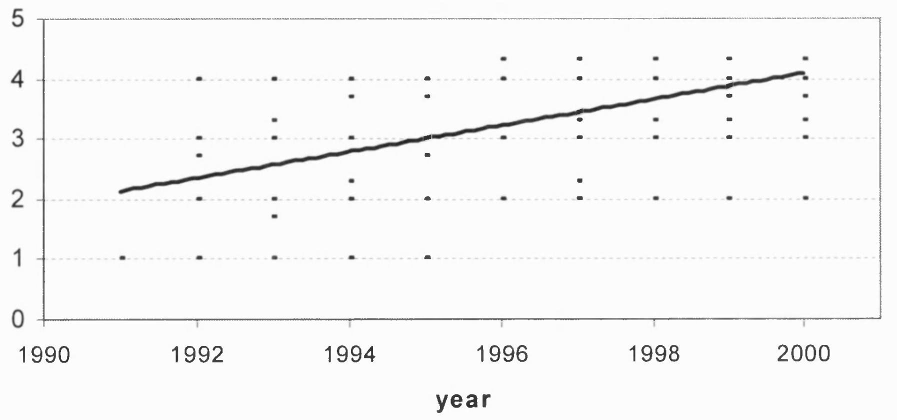


Fig. J-5D. Large-scale privatisation index

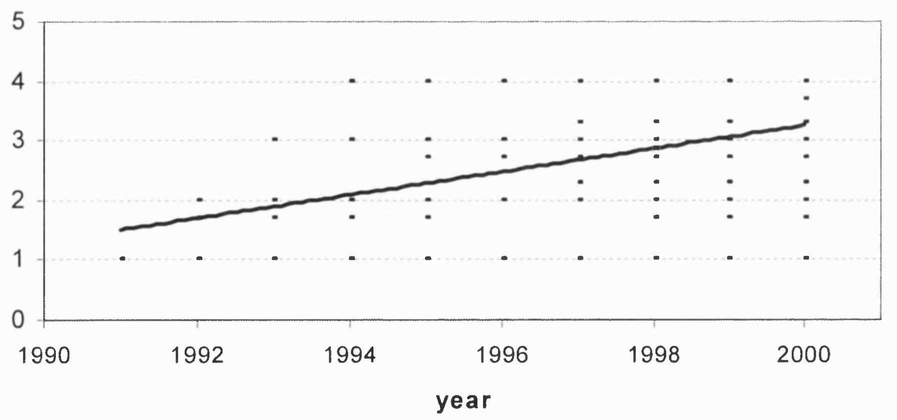


Fig. J-5E. Enterprise reform index

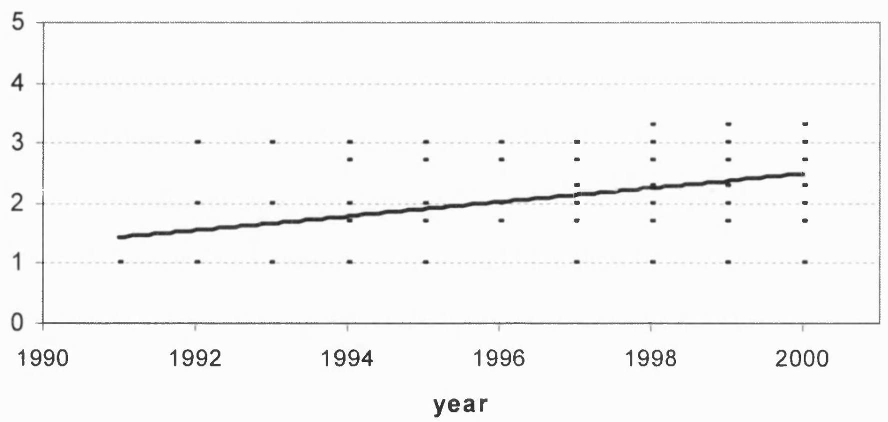
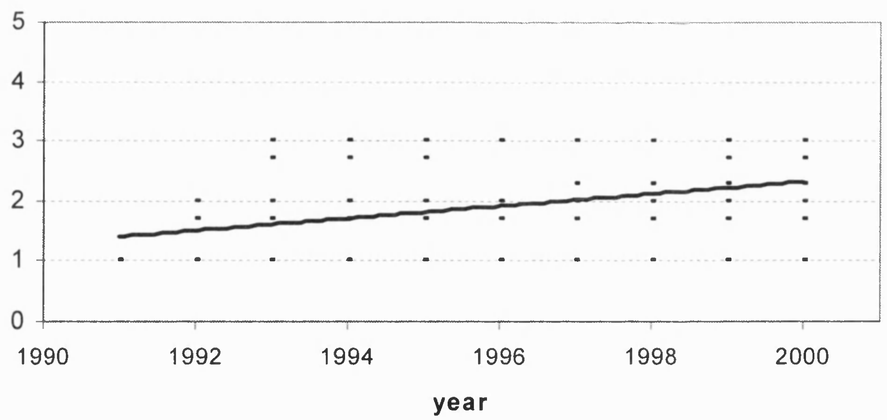


Fig. J-5F. Competition policy index



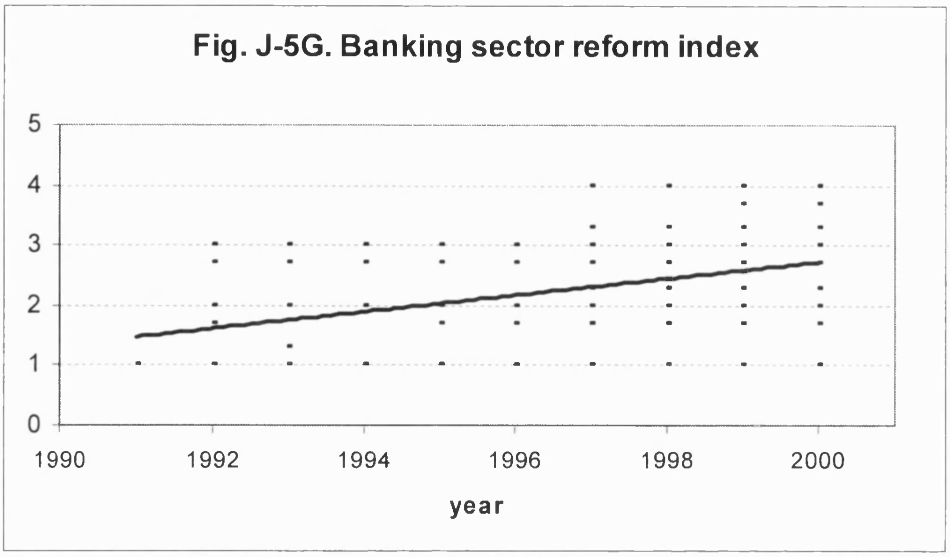


Fig. J-5G. Banking sector reform index
5
4
3
2
1
0
1990
1992
1994
1996
1998
2000
year

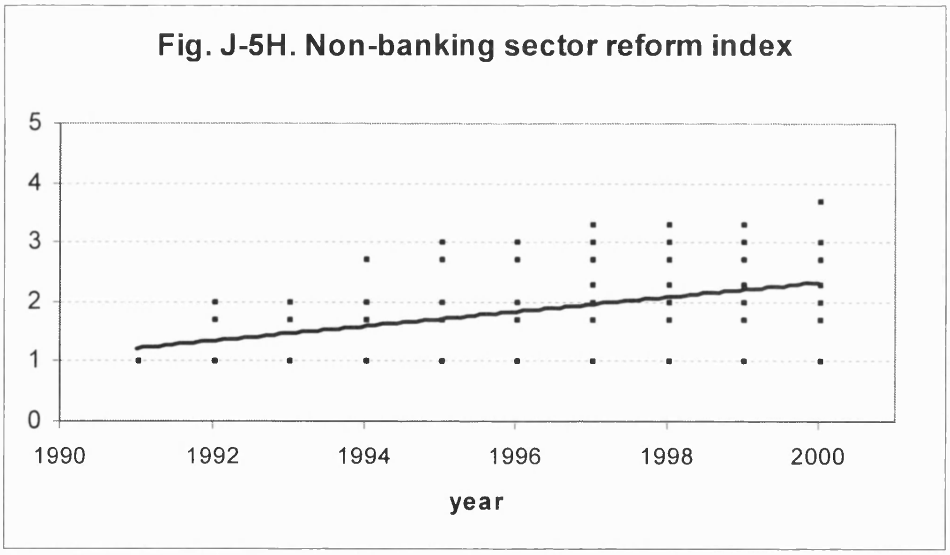


Fig. J-5H. Non-banking sector reform index
5
4
3
2
1
0
1990
1992
1994
1996
1998
2000
year

APPENDIX K

TRANSITION INDICATOR SCORES AND THE SPEEDS OF TRANSITION FOR INDIVIDUAL COUNTRIES

TABLE K-1. ALBANIA

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Price liberalisation	N/A	2.67	3.67	3.67	3.67	3.67	3.67	3.67	3.67	4.33
Speed of price liberalisation	N/A	1.67	0.37	0	0	0	0	0	0	0.18
Trade liberalisation	N/A	4	4	4	4	4	4	4	4	4.3
Speed of trade liberalisation	N/A	3	0	0	0	0	0	0	0	0.08
Small-scale privatisation	N/A	2	3	3	4	4	4	4	4	4
Speed of small-scale privatisation	N/A	0	0.5	0	0.33	0	0	0	0	0
Large-scale privatisation	N/A	1	1	1	2	2	2	2	2	2
Speed of large-scale privatisation	N/A	0	0	0	1	0	0	0	0	0
Enterprise reform	N/A	1	1	2	2	2	2	2	2	2
Speed of enterprise reform	N/A	0	0	1	0	0	0	0	0	0
Competition policy	N/A	1	1	1	1	1.7	1.7	1.7	1.7	1.7
Speed of competition policy	N/A	0	0	0	0	0.7	0	0	0	0
Banking reform	N/A	1	1.3	2	2	2	2	2	2	2.3
Speed of banking reform	N/A	0	0.3	0.54	0	0	0	0	0	0.15
Non-banking reform	N/A	1	1	1	1	1.7	1.7	1.7	1.7	1.7
Speed of banking reform	N/A	0	0	0	0	0.7	0	0	0	0
Average index	N/A	1.71	2	2.21	2.46	2.63	2.63	2.63	2.63	2.79
Speed of average index	N/A	0.58	0.15	0.19	0.17	0.18	0	0	0	0.05

TABLE K-2. ARMENIA

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Price liberalisation	1	3.33	3.67	3.67	3.67	4.33	4.33	4.33	4.33	4.33
Speed of price liberalisation	0	2.33	0.1	0	0	0.18	0	0	0	0
Trade liberalisation	1	2	2	2	3	4	4	4	4	4
Speed of trade liberalisation	0	1	0	0	0.5	0.33	0	0	0	0
Small-scale privatisation	1	2	2	2.3	2.7	3	3	3.3	3.3	3.3
Speed of small-scale privatisation	0	1	0	0.15	0.17	0.11	0	0.1	0	0
Large-scale privatisation	1	1	1	1	2	3	3	3	3	3
Speed of large-scale privatisation	0	0	0	0	1	0.5	0	0	0	0
Enterprise reform	1	1	1	1	2	2	2	2	2	2
Speed of enterprise reform	0	0	0	0	1	0	0	0	0	0
Competition policy	1	1	1	1	1	1	1	1	1	1
Speed of competition policy	0	0	0	0	0	0	0	0	0	0
Banking reform	1	1	1	1	2	2	2.3	2.3	2.3	2.3
Speed of banking reform	0	0	0	0	1	0	0.15	0	0	0
Non-banking reform	1	1	1	1	1	1	1	2	2	2
Speed of banking reform	0	0	0	0	0	0	0	1	0	0
Average index	1	1.54	1.58	1.62	2.17	2.54	2.58	2.74	2.74	2.74
Speed of average index	0	0.54	0.01	0.02	0.46	0.14	0.02	0.14	0	0

TABLE K-3. AZERBAIJAN

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Price liberalisation	N/A	N/A	N/A	3.67	3.67	3.67	4	4	4	4
Speed of price liberalisation	N/A	N/A	N/A	0	0	0	0.09	0	0	0
Trade liberalisation	N/A	N/A	N/A	1	2	2	2.3	3	3.3	3.3
Speed of trade liberalisation	N/A	N/A	N/A	0	1	0	0.15	0.3	0.1	0
Small-scale privatisation	N/A	N/A	N/A	1	1	2	3	3.3	3.3	3.3
Speed of small-scale privatisation	N/A	N/A	N/A	0	0	1	0.5	0.1	0	0
Large-scale privatisation	N/A	N/A	N/A	1	1	1	2	2	1.7	1.7
Speed of large-scale privatisation	N/A	N/A	N/A	0	0	0	1	0	-0.15	0
Enterprise reform	N/A	N/A	N/A	1	1.7	1.7	1.7	1.7	1.7	2
Speed of enterprise reform	N/A	N/A	N/A	0	0.7	0	0	0	0	0.18
Competition policy	N/A	N/A	N/A	1	2	2	2	2	2	2
Speed of competition policy	N/A	N/A	N/A	0	1	0	0	0	0	0
Banking reform	N/A	N/A	N/A	1	2	2	2	2	2	2
Speed of banking reform	N/A	N/A	N/A	0	1	0	0	0	0	0
Non-banking reform	N/A	N/A	N/A	1	1	1	1	1.7	1.7	1.7
Speed of banking reform	N/A	N/A	N/A	0	0	0	0	0.7	0	0
Average index	N/A	N/A	N/A	1.33	1.8	1.92	2.25	2.46	2.46	2.5
Speed of average index	N/A	N/A	N/A	0	0.46	0.13	0.22	0.14	-0.01	0.02

TABLE K-4. BELARUS

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Price liberalisation	1	2.33	2.33	2.67	3.67	3.67	4	2.67	2.33	2.33
Speed of price liberalisation	0	1.33	0	0.15	0.37	0	0.09	-0.33	-0.13	0
Trade liberalisation	1	1	1	1	2	2	1	1	1	1.7
Speed of trade liberalisation	0	0	0	0	1	0	-0.5	0	0	0.7
Small-scale privatisation	1	1	2	2	2	2	2	2	2	2
Speed of small-scale privatisation	0	0	1	0	0	0	0	0	0	0
Large-scale privatisation	1	1	1.7	1.7	1.7	1	1	1	1	1
Speed of large-scale privatisation	0	0	0.7	0	0	-0.41	0	0	0	0
Enterprise reform	1	1	1	1	1.7	1.7	1	1	1	1
Speed of enterprise reform	0	0	0	0	0.7	0	-0.41	0	0	0
Competition policy	1	1	2	2	2	2	2	2	2	2
Speed of competition policy	0	0	1	0	0	0	0	0	0	0
Banking reform	1	1	1	1	2	1	1	1	1	1
Speed of banking reform	0	0	0	0	1	-0.5	0	0	0	0
Non-banking reform	1	2	2	2	2	2	2	2	2	2
Speed of banking reform	0	1	0	0	0	0	0	0	0	0
Average index	1	1.29	1.63	1.67	2.13	1.92	1.75	1.58	1.54	1.63
Speed of average index	0	0.29	0.34	0.02	0.38	-0.11	-0.1	-0.04	-0.02	0.09

TABLE K-5. BULGARIA

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Price liberalisation	N/A	4.33	4.33	4	2.67	2.67	4	4	4	4
Speed of price liberalisation	N/A	0	0	-0.08	-0.33	0	0.5	0	0	0
Trade liberalisation	N/A	3	3	4	4	4	4	4	4.3	4.3
Speed of trade liberalisation	N/A	0	0	0.33	0	0	0	0	0.08	0
Small-scale privatisation	N/A	1	1.7	2	3	3	3	3	3.3	3.7
Speed of small-scale privatisation	N/A	0	0.7	0.18	0.5	0	0	0	0.1	0.12
Large-scale privatisation	N/A	1.7	2	2	2	2	3	3	3	3.7
Speed of large-scale privatisation	N/A	0.7	0.18	0	0	0	0.5	0	0	0.23
Enterprise reform	N/A	1	1	2	2	2	2.3	2.3	2.3	2.3
Speed of enterprise reform	N/A	0	0	1	0	0	0.15	0	0	0
Competition policy	N/A	2	2	2	2	2	2.3	2.3	2.3	2.3
Speed of competition policy	N/A	0	0	0	0	0	0.15	0	0	0
Banking reform	N/A	1.7	2	2	2	2	2.7	2.7	2.7	3
Speed of banking reform	N/A	0.7	0.18	0	0	0	0.35	0	0	0.11
Non-banking reform	N/A	1	1	1	2	2	2	2	2	2
Speed of banking reform	N/A	0	0	0	1	0	0	0	0	0
Average index	N/A	1.97	2.13	2.38	2.46	2.46	2.91	2.91	2.99	3.16
Speed of average index	N/A	0.18	0.13	0.18	0.15	0	0.21	0	0.02	0.06

TABLE K-6. CROATIA

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Price liberalisation	N/A	4	4	4	4	4	4	4	4	4
Speed of price liberalisation	N/A	0.09	0	0	0	0	0	0	0	0
Trade liberalisation	N/A	3	3	4	4	4	4	4	4	4.3
Speed of trade liberalisation	N/A	0	0	0.33	0	0	0	0	0	0.08
Small-scale privatisation	N/A	3	4	4	4	4.3	4.3	4.3	4.3	4.3
Speed of small-scale privatisation	N/A	0	0.33	0	0	0.08	0	0	0	0
Large-scale privatisation	N/A	2	2	2	3	3	3	3	3	3
Speed of large-scale privatisation	N/A	1	0	0	0.5	0	0	0	0	0
Enterprise reform	N/A	1	1	2	2	2.7	2.7	2.7	2.7	2.7
Speed of enterprise reform	N/A	0	0	1	0	0.35	0	0	0	0
Competition policy	N/A	1	1	1	1	2	2.3	2.3	2.3	2.3
Speed of competition policy	N/A	0	0	0	0	1	0.15	0	0	0
Banking reform	N/A	1	2	2.7	2.7	2.7	2.7	2.7	3	3.3
Speed of banking reform	N/A	0	1	0.35	0	0	0	0	0.11	0.1
Non-banking reform	N/A	1	1	2	2	2	2.3	2.3	2.3	2.3
Speed of banking reform	N/A	0	0	1	0	0	0.15	0	0	0
Average index	N/A	2	2.25	2.71	2.84	3.09	3.16	3.16	3.2	3.28
Speed of average index	N/A	0.14	0.17	0.34	0.06	0.18	0.04	0	0.01	0.02

TABLE K-7. CZECH REPUBLIC

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Price liberalisation	N/A	4	4	4	4	4	4.33	4.33	4.33	4.33
Speed of price liberalisation	N/A	0	0	0	0	0	0.08	0	0	0
Trade liberalisation	N/A	4	4	4	4	4.3	4.3	4.3	4.3	4.3
Speed of trade liberalisation	N/A	0.33	0	0	0	0.08	0	0	0	0
Small-scale privatisation	N/A	4	4	4	4	4.3	4.3	4.3	4.3	4.3
Speed of small-scale privatisation	N/A	0.33	0	0	0	0.08	0	0	0	0
Large-scale privatisation	N/A	2	3	4	4	4	4	4	4	4
Speed of large-scale privatisation	N/A	1	0.5	0.33	0	0	0	0	0	0
Enterprise reform	N/A	2	3	3	3	3	3	3	3	3.3
Speed of enterprise reform	N/A	0	0.5	0	0	0	0	0	0	0.1
Competition policy	N/A	2	2.7	2.7	2.7	3	3	3	3	3
Speed of competition policy	N/A	0	0.35	0	0	0.11	0	0	0	0
Banking reform	N/A	3	3	3	3	3	3	3	3.3	3.3
Speed of banking reform	N/A	0.5	0	0	0	0	0	0	0.1	0
Non-banking reform	N/A	1	2	2.7	2.7	2.7	2.7	3	3	3
Speed of banking reform	N/A	0	1	0.35	0	0	0	0.11	0	0
Average index	N/A	2.75	3.21	3.43	3.43	3.54	3.58	3.62	3.65	3.69
Speed of average index	N/A	0.27	0.29	0.09	0	0.03	0.01	0.01	0.01	0.01

TABLE K-8. ESTONIA

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Price liberalisation	N/A	2.67	4.33	4.33	4.33	4.33	4.33	4.33	4.33	4.33
Speed of price liberalisation	N/A	0	0.62	0	0	0	0	0	0	0
Trade liberalisation	N/A	3	3	4	4	4	4	4	4	4.3
Speed of trade liberalisation	N/A	0.5	0	0.33	0	0	0	0	0	0.08
Small-scale privatisation	N/A	2	3	4	4	4.3	4.3	4.3	4.3	4.3
Speed of small-scale privatisation	N/A	1	0.5	0.33	0	0.08	0	0	0	0
Large-scale privatisation	N/A	1	2	3	4	4	4	4	4	4
Speed of large-scale privatisation	N/A	0	1	0.5	0.33	0	0	0	0	0
Enterprise reform	N/A	2	3	3	3	3	3	3	3	3.3
Speed of enterprise reform	N/A	1	0.5	0	0	0	0	0	0	0.1
Competition policy	N/A	1	2	2	2	2	2	2	2.7	2.7
Speed of competition policy	N/A	0	1	0	0	0	0	0	0.35	0
Banking reform	N/A	2	3	3	3	3	3.3	3.3	3.7	3.7
Speed of banking reform	N/A	1	0.5	0	0	0	0.1	0	0.12	0
Non-banking reform	N/A	1	1.7	1.7	1.7	2	3	3	3	3
Speed of banking reform	N/A	0	0.7	0	0	0.18	0.5	0	0	0
Average index	N/A	1.83	2.75	3.13	3.25	3.33	3.49	3.49	3.63	3.7
Speed of average index	N/A	0.44	0.6	0.15	0.04	0.03	0.08	0	0.06	0.02

TABLE K-9. FYR MACEDONIA

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Price liberalisation	N/A	4	4	4	4	4	4	4	4	4
Speed of price liberalisation	N/A	0.09	0	0	0	0	0	0	0	0
Trade liberalisation	N/A	3	3	4	4	4	4	4	4	4
Speed of trade liberalisation	N/A	0	0	0.33	0	0	0	0	0	0
Small-scale privatisation	N/A	3	3	4	4	4	4	4	4	4
Speed of small-scale privatisation	N/A	0	0	0.33	0	0	0	0	0	0
Large-scale privatisation	N/A	1	2	2	2	3	3	3	3	3
Speed of large-scale privatisation	N/A	0	1	0	0	0.5	0	0	0	0
Enterprise reform	N/A	1	1	2	2	2	2	2	2	2.3
Speed of enterprise reform	N/A	0	0	1	0	0	0	0	0	0.15
Competition policy	N/A	1	1	1	1	1	1	1	1	2
Speed of competition policy	N/A	0	0	0	0	0	0	0	0	1
Banking reform	N/A	1	1.3	2	3	3	3	3	3	3
Speed of banking reform	N/A	0	0.3	0.54	0.5	0	0	0	0	0
Non-banking reform	N/A	1	1	1	1	1	1	1.7	1.7	1.7
Speed of banking reform	N/A	0	0	0	0	0	0	0.7	0	0
Average index	N/A	1.88	2.04	2.5	2.63	2.75	2.75	2.84	2.84	3
Speed of average index	N/A	0.01	0.16	0.28	0.06	0.06	0	0.09	0	0.14

TABLE K-10. GEORGIA

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Price liberalisation	1	3.33	3.67	3.67	3.67	4	4	4.33	4.33	4.33
Speed of price liberalisation	0	2.33	0.1	0	0	0.09	0	0.08	0	0
Trade liberalisation	1	1	1	1	2	3	4	4	4	4.3
Speed of trade liberalisation	0	0	0	0	1	0.5	0.33	0	0	0.08
Small-scale privatisation	1	1	2	2	3	4	4	4	4	4
Speed of small-scale privatisation	0	0	1	0	0.5	0.33	0	0	0	0
Large-scale privatisation	1	1	1	1	2	3	3.3	3.3	3.3	3.3
Speed of large-scale privatisation	0	0	0	0	1	0.5	0.1	0	0	0
Enterprise reform	1	1	1	1	2	2	2	2	2	2
Speed of enterprise reform	0	0	0	0	1	0	0	0	0	0
Competition policy	1	1	1	1	1	2	2	2	2	2
Speed of competition policy	0	0	0	0	0	1	0	0	0	0
Banking reform	1	1	1	1	2	2	2.3	2.3	2.3	2.3
Speed of banking reform	0	0	0	0	1	0	0.15	0	0	0
Non-banking reform	1	1	1	1	1	1	1	1	1	1.7
Speed of banking reform	0	0	0	0	0	0	0	0	0	0.7
Average index	1	1.29	1.46	1.46	2.08	2.63	2.83	2.87	2.87	2.99
Speed of average index	0	0.29	0.14	0	0.56	0.3	0.07	0.01	0	0.1

TABLE K-11. HUNGARY

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Price liberalisation	N/A	4.33	4.33	4.33	4.33	4.33	4.33	4.33	4.33	4.33
Speed of price liberalisation	N/A	0	0	0	0	0	0	0	0	0
Trade liberalisation	N/A	4	4	4.3	4.3	4.3	4.3	4.3	4.3	4.3
Speed of trade liberalisation	N/A	0	0	0.08	0	0	0	0	0	0
Small-scale privatisation	N/A	2	3	3.7	3.7	4	4.3	4.3	4.3	4.3
Speed of small-scale privatisation	N/A	1	0.5	0.23	0	0.08	0.08	0	0	0
Large-scale privatisation	N/A	2	3	3	4	4	4	4	4	4
Speed of large-scale privatisation	N/A	0	0.5	0	0.33	0	0	0	0	0
Enterprise reform	N/A	3	3	3	3	3	3	3.3	3.3	3.3
Speed of enterprise reform	N/A	0.5	0	0	0	0	0	0.1	0	0
Competition policy	N/A	2	2	3	3	3	3	3	3	3
Speed of competition policy	N/A	0	0	0.5	0	0	0	0	0	0
Banking reform	N/A	2	3	3	3	3	4	4	4	4
Speed of banking reform	N/A	0	0.5	0	0	0	0.33	0	0	0
Non-banking reform	N/A	2	2	2	3	3	3.3	3.3	3.3	3.7
Speed of banking reform	N/A	0	0	0	0.5	0	0.1	0	0	0.12
Average index	N/A	2.67	3.04	3.29	3.54	3.58	3.78	3.82	3.82	3.87
Speed of average index	N/A	0.19	0.19	0.1	0.1	0.01	0.06	0.01	0	0.02

TABLE K-12. KAZAKHSTAN

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Price liberalisation	N/A	2.67	2.67	2.67	4	4	4	4	4	4
Speed of price liberalisation	N/A	1.67	0	0	0.5	0	0	0	0	0
Trade liberalisation	N/A	1	2	2	3	4	4	4	3	3.3
Speed of trade liberalisation	N/A	0	1	0	0.5	0.33	0	0	-0.25	0.1
Small-scale privatisation	N/A	2	2	2.3	3	3	3.3	4	4	4
Speed of small-scale privatisation	N/A	1	0	0.15	0.3	0	0.1	0.21	0	0
Large-scale privatisation	N/A	1	2	2	2	3	3	3	3	3
Speed of large-scale privatisation	N/A	0	1	0	0	0.5	0	0	0	0
Enterprise reform	N/A	1	1	1	1	2	2	2	2	2
Speed of enterprise reform	N/A	0	0	0	0	1	0	0	0	0
Competition policy	N/A	1	1	2	2	2	2	2	2	2
Speed of competition policy	N/A	0	0	1	0	0	0	0	0	0
Banking reform	N/A	1	1	1	2	2	2.3	2.3	2.3	2.3
Speed of banking reform	N/A	0	0	0	1	0	0.15	0	0	0
Non-banking reform	N/A	1	1	1.7	1.7	1.7	1.7	2	2	2.3
Speed of banking reform	N/A	0	0	0.7	0	0	0	0.18	0	0.15
Average index	N/A	1.33	1.58	1.83	2.34	2.71	2.79	2.91	2.79	2.86
Speed of average index	N/A	0.33	0.25	0.23	0.29	0.23	0.03	0.05	-0.03	0.03

TABLE K-13. KYRGYZ REPUBLIC

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Price liberalisation	1	2.33	3.67	4.33	4.33	4.33	4.33	4.33	4.33	4.33
Speed of price liberalisation	0	1.33	0.58	0.18	0	0	0	0	0	0
Trade liberalisation	1	2	2	3	4	4	4	4	4	4
Speed of trade liberalisation	0	1	0	0.5	0.33	0	0	0	0	0
Small-scale privatisation	1	2	3	4	4	4	4	4	4	4
Speed of small-scale privatisation	0	1	0.5	0.33	0	0	0	0	0	0
Large-scale privatisation	1	2	2	3	3	3	3	3	3	3
Speed of large-scale privatisation	0	1	0	0.5	0	0	0	0	0	0
Enterprise reform	1	1	1	2	2	2	2	2	2	2
Speed of enterprise reform	0	0	0	1	0	0	0	0	0	0
Competition policy	1	1	1	2	2	2	2	2	2	2
Speed of competition policy	0	0	0	1	0	0	0	0	0	0
Banking reform	1	1	1	2	2	2	2.7	2.7	2.3	2.3
Speed of banking reform	0	0	0	1	0	0	0.35	0	-0.15	0
Non-banking reform	1	1	1	1	1.7	2	2	2	2	2
Speed of banking reform	0	0	0	0	0.7	0.18	0	0	0	0
Average index	1	1.54	1.83	2.67	2.88	2.92	3	3	2.95	2.95
Speed of average index	0	0.54	0.14	0.56	0.13	0.02	0.04	0	-0.02	0

TABLE K-14. LATVIA

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Price liberalisation	N/A	4	4.33	4.33	4.33	4.33	4.33	4.33	4.33	4.33
Speed of price liberalisation	N/A	0.5	0.08	0	0	0	0	0	0	0
Trade liberalisation	N/A	2	3	4	4	4	4	4	4.3	4.3
Speed of trade liberalisation	N/A	1	0.5	0.33	0	0	0	0	0.08	0
Small-scale privatisation	N/A	2	3	4	4	4	4	4	4	4.3
Speed of small-scale privatisation	N/A	1	0.5	0.33	0	0	0	0	0	0.08
Large-scale privatisation	N/A	2	2	2	2	3	3	3	3	3
Speed of large-scale privatisation	N/A	1	0	0	0	0.5	0	0	0	0
Enterprise reform	N/A	2	3	3	3	3	2.7	2.7	2.7	2.7
Speed of enterprise reform	N/A	1	0.5	0	0	0	-0.1	0	0	0
Competition policy	N/A	2	2	2	2	2	2.3	2.3	2.3	2.3
Speed of competition policy	N/A	1	0	0	0	0	0.15	0	0	0
Banking reform	N/A	2	2	3	3	3	3	2.7	3	3
Speed of banking reform	N/A	1	0	0.5	0	0	0	-0.1	0.11	0
Non-banking reform	N/A	1	1	2	2	2	2.3	2.3	2.3	2.3
Speed of banking reform	N/A	0	0	1	0	0	0.15	0	0	0
Average index	N/A	2.13	2.54	3.04	3.04	3.17	3.2	3.17	3.24	3.28
Speed of average index	N/A	0.81	0.2	0.27	0	0.06	0.03	-0.01	0.02	0.01

TABLE K-15. LITHUANIA

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Price liberalisation	N/A	2.67	4	4	4	4	4	4	4	4
Speed of price liberalisation	N/A	0	0.5	0	0	0	0	0	0	0
Trade liberalisation	N/A	2	3	4	4	4	4	4	4	4
Speed of trade liberalisation	N/A	1	0.5	0.33	0	0	0	0	0	0
Small-scale privatisation	N/A	2.7	3.3	4	4	4	4	4	4.3	4.3
Speed of small-scale privatisation	N/A	1.7	0.22	0.21	0	0	0	0	0.08	0
Large-scale privatisation	N/A	2	3	3	3	3	3	3	3	3
Speed of large-scale privatisation	N/A	1	0.5	0	0	0	0	0	0	0
Enterprise reform	N/A	1	2	2	2	3	2.7	2.7	2.7	2.7
Speed of enterprise reform	N/A	0	1	0	0	0.5	-0.1	0	0	0
Competition policy	N/A	1	2	2	2	2	2.3	2.3	2.3	2.7
Speed of competition policy	N/A	0	1	0	0	0	0.15	0	0	0.17
Banking reform	N/A	1	2	2	3	3	3	3	3	3
Speed of banking reform	N/A	0	1	0	0.5	0	0	0	0	0
Non-banking reform	N/A	1	1.7	2	2	2	2.3	2.3	2.7	3
Speed of banking reform	N/A	0	0.7	0.18	0	0	0.15	0	0.17	0.11
Average index	N/A	1.67	2.63	2.88	3	3.13	3.16	3.16	3.25	3.34
Speed of average index	N/A	0.46	0.68	0.09	0.06	0.06	0.03	0	0.03	0.04

TABLE K-16. MOLDOVA

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Price liberalisation	1	3.33	3.67	3.67	3.67	3.67	3.67	3.67	3.67	3.67
Speed of price liberalisation	0	2.33	0.1	0	0	0	0	0	0	0
Trade liberalisation	1	2	2	2	4	4	4	4	4	4
Speed of trade liberalisation	0	1	0	0	1	0	0	0	0	0
Small-scale privatisation	1	1	1	2	3	3	3	3.3	3.3	3.3
Speed of small-scale privatisation	0	0	0	1	0.5	0	0	0.1	0	0
Large-scale privatisation	1	1	2	2	3	3	3	3	3	3
Speed of large-scale privatisation	0	0	1	0	0.5	0	0	0	0	0
Enterprise reform	1	1	1	2	2	2	2	2	2	2
Speed of enterprise reform	0	0	0	1	0	0	0	0	0	0
Competition policy	1	1.7	1.7	1.7	2	2	2	2	2	2
Speed of competition policy	0	0.7	0	0	0.18	0	0	0	0	0
Banking reform	1	1	2	2	2	2	2	2.3	2.3	2.3
Speed of banking reform	0	0	1	0	0	0	0	0.15	0	0
Non-banking reform	1	1	1	2	2	2	2	2	2	2
Speed of banking reform	0	0	0	1	0	0	0	0	0	0
Average index	1	1.5	1.8	2.17	2.71	2.71	2.71	2.78	2.78	2.78
Speed of average index	0	0.5	0.26	0.38	0.27	0	0	0.03	0	0

TABLE K-17. POLAND

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Price liberalisation	N/A	4	4	4	4	4	4	4.33	4.33	4.33
Speed of price liberalisation	N/A	0.09	0	0	0	0	0	0.08	0	0
Trade liberalisation	N/A	3	4	4	4	4.3	4.3	4.3	4.3	4.3
Speed of trade liberalisation	N/A	0	0.33	0	0	0.08	0	0	0	0
Small-scale privatisation	N/A	4	4	4	4	4.3	4.3	4.3	4.3	4.3
Speed of small-scale privatisation	N/A	0.33	0	0	0	0.08	0	0	0	0
Large-scale privatisation	N/A	2	2	3	3	3	3.3	3.3	3.3	3.3
Speed of large-scale privatisation	N/A	0	0	0.5	0	0	0.1	0	0	0
Enterprise reform	N/A	2	3	3	3	3	3	3	3	3
Speed of enterprise reform	N/A	0	0.5	0	0	0	0	0	0	0
Competition policy	N/A	2	3	3	3	3	3	3	3	3
Speed of competition policy	N/A	0	0.5	0	0	0	0	0	0	0
Banking reform	N/A	2	3	3	3	3	3	3.3	3.3	3.3
Speed of banking reform	N/A	0	0.5	0	0	0	0	0.1	0	0
Non-banking reform	N/A	2	2	2	3	3	3.3	3.3	3.3	3.7
Speed of banking reform	N/A	0	0	0	0.5	0	0.1	0	0	0.12
Average index	N/A	2.63	3.13	3.25	3.38	3.45	3.53	3.6	3.6	3.65
Speed of average index	N/A	0.05	0.23	0.06	0.06	0.02	0.03	0.02	0	0.02

TABLE K-18. ROMANIA

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Price liberalisation	N/A	2.67	3.67	4	4	4	4	4.33	4.33	4.33
Speed of price liberalisation	N/A	0	0.37	0.09	0	0	0	0.08	0	0
Trade liberalisation	N/A	3	3	4	4	3	4	4	4	4
Speed of trade liberalisation	N/A	2	0	0.33	0	-0.25	0.33	0	0	0
Small-scale privatisation	N/A	2	2	2.3	2.7	3	3.3	3.3	3.7	3.7
Speed of small-scale privatisation	N/A	1	0	0.15	0.17	0.11	0.1	0	0.12	0
Large-scale privatisation	N/A	1.7	2	2	2	2.7	2.7	2.7	2.7	3
Speed of large-scale privatisation	N/A	0	0.18	0	0	0.35	0	0	0	0.11
Enterprise reform	N/A	1	2	2	2	2	2	2	2	2
Speed of enterprise reform	N/A	0	1	0	0	0	0	0	0	0
Competition policy	N/A	1	1	1	1	1	2.3	2.3	2.3	2.3
Speed of competition policy	N/A	0	0	0	0	0	1.3	0	0	0
Banking reform	N/A	1	1	2	3	3	2.7	2.3	2.7	2.7
Speed of banking reform	N/A	0	0	1	0.5	0	-0.1	-0.15	0.17	0
Non-banking reform	N/A	1	1	2	2	2	2	2	2	2
Speed of banking reform	N/A	0	0	1	0	0	0	0	0	0
Average index	N/A	1.67	1.96	2.41	2.59	2.59	2.88	2.87	2.97	3
Speed of average index	N/A	0.38	0.19	0.32	0.08	0.03	0.2	-0.01	0.04	0.01

TABLE K-19. RUSSIA

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Price liberalisation	N/A	3.67	3.67	3.67	3.67	3.67	3.67	3.33	3.33	4
Speed of price liberalisation	N/A	2.67	0	0	0	0	0	-0.09	0	0.2
Trade liberalisation	N/A	3	3	3	3	4	4	2.3	2.3	2.3
Speed of trade liberalisation	N/A	2	0	0	0	0.33	0	-0.43	0	0
Small-scale privatisation	N/A	2	3	3	4	4	4	4	4	4
Speed of small-scale privatisation	N/A	1	0.5	0	0.33	0	0	0	0	0
Large-scale privatisation	N/A	2	3	3	3	3	3.3	3.3	3.3	3.3
Speed of large-scale privatisation	N/A	1	0.5	0	0	0	0.1	0	0	0
Enterprise reform	N/A	1	1	1.7	2	2	2	2	1.7	2
Speed of enterprise reform	N/A	0	0	0.7	0.18	0	0	0	-0.15	0.18
Competition policy	N/A	2	2	2	2	2	2.3	2.3	2.3	2.3
Speed of competition policy	N/A	0	0	0	0	0	0.15	0	0	0
Banking reform	N/A	1	1	2	2	2	2.3	2	1.7	1.7
Speed of banking reform	N/A	0	0	1	0	0	0.15	-0.13	-0.15	0
Non-banking reform	N/A	1	1.7	1.7	2	3	3	1.7	1.7	1.7
Speed of banking reform	N/A	0	0.7	0	0.18	0.5	0	-0.43	0	0
Average index	N/A	1.96	2.3	2.51	2.71	2.96	3.07	2.62	2.54	2.66
Speed of average index	N/A	0.83	0.21	0.21	0.09	0.1	0.05	-0.14	-0.04	0.05

TABLE K-20. SLOVAK REPUBLIC

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Price liberalisation	N/A	4	4	4	4	4	4	4	4	4
Speed of price liberalisation	N/A	0	0	0	0	0	0	0	0	0
Trade liberalisation	N/A	4	4	4	4	4.3	4	4.3	4.3	4.3
Speed of trade liberalisation	N/A	0.33	0	0	0	0.08	-0.07	0.08	0	0
Small-scale privatisation	N/A	4	4	4	4	4.3	4.3	4.3	4.3	4.3
Speed of small-scale privatisation	N/A	0.33	0	0	0	0.08	0	0	0	0
Large-scale privatisation	N/A	2	3	3	3	3	4	4	4	4
Speed of large-scale privatisation	N/A	1	0.5	0	0	0	0.33	0	0	0
Enterprise reform	N/A	2	3	3	3	3	2.7	2.7	3	3
Speed of enterprise reform	N/A	0	0.5	0	0	0	-0.1	0	0.11	0
Competition policy	N/A	2	2	3	3	3	3	3	3	3
Speed of competition policy	N/A	0	0	0.5	0	0	0	0	0	0
Banking reform	N/A	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	3
Speed of banking reform	N/A	0.35	0	0	0	0	0	0	0	0.11
Non-banking reform	N/A	1	2	2.7	2.7	2.7	2.3	2.3	2.3	2.3
Speed of banking reform	N/A	0	1	0.35	0	0	-0.15	0	0	0
Average index	N/A	2.71	3.09	3.3	3.3	3.38	3.38	3.41	3.45	3.49
Speed of average index	N/A	0.25	0.25	0.11	0	0.02	0	0.01	0.01	0.01

TABLE K-21. SLOVENIA

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Price liberalisation	N/A	3.67	3.67	3.67	3.67	3.67	3.67	4	4	4
Speed of price liberalisation	N/A	0	0	0	0	0	0	0.09	0	0
Trade liberalisation	N/A	3	4	4	4	4.3	4.3	4.3	4.3	4.3
Speed of trade liberalisation	N/A	0	0.33	0	0	0.08	0	0	0	0
Small-scale privatisation	N/A	3	4	4	4	4.3	4.3	4.3	4.3	4.3
Speed of small-scale privatisation	N/A	0	0.33	0	0	0.08	0	0	0	0
Large-scale privatisation	N/A	1	2	2	2.7	2.7	3	3	3	3.3
Speed of large-scale privatisation	N/A	0	1	0	0.35	0	0.11	0	0	0.1
Enterprise reform	N/A	1	2	2.7	2.7	2.7	2.7	2.7	2.7	2.7
Speed of enterprise reform	N/A	0	1	0.35	0	0	0	0	0	0
Competition policy	N/A	1	2	2	2	2	2	2.3	2.3	2.7
Speed of competition policy	N/A	0	1	0	0	0	0	0.15	0	0.17
Banking reform	N/A	2	3	3	3	3	3	3	3.3	3.3
Speed of banking reform	N/A	1	0.5	0	0	0	0	0	0.1	0
Non-banking reform	N/A	2	2	2.7	2.7	2.7	2.7	2.7	2.7	2.7
Speed of banking reform	N/A	0	0	0.35	0	0	0	0	0	0
Average index	N/A	2.08	2.83	3.01	3.1	3.17	3.21	3.29	3.33	3.41
Speed of average index	N/A	0.13	0.52	0.09	0.04	0.02	0.01	0.03	0.01	0.03

TABLE K-22. TAJIKISTAN

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Price liberalisation	1	N/A	2.33	2.33	3.33	N/A	3.67	3.67	3.67	3.67
Speed of price liberalisation	0	N/A	-0.13	0	0.43	N/A	0	0	0	0
Trade liberalisation	1	N/A	1	1	2	N/A	2	2.7	2.7	3.3
Speed of trade liberalisation	0	N/A	0	0	1	N/A	0	0.35	0	0.22
Small-scale privatisation	1	N/A	2	2	2	N/A	2.3	3	3	3.3
Speed of small-scale privatisation	0	N/A	0	0	0	N/A	0.15	0.3	0	0.1
Large-scale privatisation	1	N/A	1	1	2	N/A	2	2	2.3	2.3
Speed of large-scale privatisation	0	N/A	0	0	1	N/A	0	0	0.15	0
Enterprise reform	1	N/A	1	1	1	N/A	1	1.7	1.7	1.7
Speed of enterprise reform	0	N/A	0	0	0	N/A	0	0.7	0	0
Competition policy	1	N/A	1.7	1.7	1.7	N/A	1.7	1.7	1.7	1.7
Speed of competition policy	0	N/A	0.7	0	0	N/A	0	0	0	0
Banking reform	1	N/A	1	1	1	N/A	1	1	1	1
Speed of banking reform	0	N/A	0	0	0	N/A	0	0	0	0
Non-banking reform	1	N/A	1	1	1	N/A	1	1	1	1
Speed of banking reform	0	N/A	0	0	0	N/A	0	0	0	0
Average index	1	N/A	1.38	1.38	1.75	N/A	1.83	2.1	2.13	2.25
Speed of average index	0	N/A	0.07	0	0.3	N/A	0.02	0.17	0.02	0.04

TABLE K-23. TURKMENISTAN

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Price liberalisation	1	N/A	N/A	N/A	N/A	N/A	2.67	2.67	2.67	2.67
Speed of price liberalisation	0	N/A	N/A	N/A	N/A	N/A	0	0	0	0
Trade liberalisation	1	N/A	N/A	N/A	N/A	N/A	1	1	1	1
Speed of trade liberalisation	0	N/A	N/A	N/A	N/A	N/A	0	0	0	0
Small-scale privatisation	1	N/A	N/A	N/A	N/A	N/A	2	2	2	2
Speed of small-scale privatisation	0	N/A	N/A	N/A	N/A	N/A	0.18	0	0	0
Large-scale privatisation	1	N/A	N/A	N/A	N/A	N/A	2	1.7	1.7	1.7
Speed of large-scale privatisation	0	N/A	N/A	N/A	N/A	N/A	1	-0.15	0	0
Enterprise reform	1	N/A	N/A	N/A	N/A	N/A	1.7	1.7	1.7	1
Speed of enterprise reform	0	N/A	N/A	N/A	N/A	N/A	0.7	0	0	-0.41
Competition policy	1	N/A	N/A	N/A	N/A	N/A	1	1	1	1
Speed of competition policy	0	N/A	N/A	N/A	N/A	N/A	0	0	0	0
Banking reform	1	N/A	N/A	N/A	N/A	N/A	1	1	1	1
Speed of banking reform	0	N/A	N/A	N/A	N/A	N/A	0	0	0	0
Non-banking reform	1	N/A	N/A	N/A	N/A	N/A	1	1	1	1
Speed of banking reform	0	N/A	N/A	N/A	N/A	N/A	0	0	0	0
Average index	1	N/A	N/A	N/A	N/A	N/A	1.55	1.51	1.51	1.42
Speed of average index	0	N/A	N/A	N/A	N/A	N/A	0.24	-0.02	0	-0.05

TABLE K-24. UKRAINE

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Price liberalisation	1	1	1	2.67	3.67	3.67	4	4	4	4
Speed of price liberalisation	0	0	0	1.67	0.37	0	0.09	0	0	0
Trade liberalisation	1	1	1	1	3	3	3	2.7	3	3
Speed of trade liberalisation	0	0	0	0	2	0	0	-0.1	0.11	0
Small-scale privatisation	1	1	2	2	2	3	3.3	3.3	3.3	3.3
Speed of small-scale privatisation	0	0	1	0	0	0.5	0.1	0	0	0
Large-scale privatisation	1	1	1	1	2	2	2.3	2.3	2.3	2.7
Speed of large-scale privatisation	0	0	0	0	1	0	0.15	0	0	0.17
Enterprise reform	1	1	1	1	2	2	2	2	2	2
Speed of enterprise reform	0	0	0	0	1	0	0	0	0	0
Competition policy	1	2	2	2	2	2	2.3	2.3	2.3	2.3
Speed of competition policy	0	1	0	0	0	0	0.15	0	0	0
Banking reform	1	1	1	1	2	2	2	2	2	2
Speed of banking reform	0	0	0	0	1	0	0	0	0	0
Non-banking reform	1	1.7	1.7	1.7	2	2	2	2	2	2
Speed of banking reform	0	0.7	0	0	0.18	0	0	0	0	0
Average index	1	1.21	1.34	1.55	2.33	2.46	2.61	2.58	2.61	2.66
Speed of average index	0	0.21	0.13	0.21	0.69	0.06	0.06	-0.01	0.01	0.02

TABLE K-25. UZBEKISTAN

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Price liberalisation	1	2.67	2.67	3.67	3.67	3.67	3.33	2.67	2.67	2.67
Speed of price liberalisation	0	1.67	0	0.37	0	0	-0.09	-0.2	0	0
Trade liberalisation	1	1	1	2	2	2	1.7	1.7	1	1
Speed of trade liberalisation	0	0	0	1	0	0	-0.15	0	-0.41	0
Small-scale privatisation	1	1	2	3	3	3	3	3	3	3
Speed of small-scale privatisation	0	0	1	0.5	0	0	0	0	0	0
Large-scale privatisation	1	1	1	2	2.7	2.7	2.7	2.7	2.7	2.7
Speed of large-scale privatisation	0	0	0	1	0.35	0	0	0	0	0
Enterprise reform	1	1	1	1	2	2	2	2	2	1.7
Speed of enterprise reform	0	0	0	0	1	0	0	0	0	-0.15
Competition policy	1	1	2	2	2	2	2	2	2	2
Speed of competition policy	0	0	1	0	0	0	0	0	0	0
Banking reform	1	1	1	1	1.7	1.7	1.7	1.7	1.7	1.7
Speed of banking reform	0	0	0	0	0.7	0	0	0	0	0
Non-banking reform	1	1	1	2	2	2	2	2	2	2
Speed of banking reform	0	0	0	1	0	0	0	0	0	0
Average index	1	1.21	1.46	2.08	2.38	2.38	2.3	2.22	2.13	2.1
Speed of average index	0	0.21	0.25	0.48	0.26	0	-0.03	-0.03	-0.05	-0.02

APPENDIX L

SOME DETAILED RESULTS OF REGRESSIONS AND TESTS FOR CHAPTER 3

This appendix contains three examples of more detailed results of regressions and tests for chapter three. The first example is the results of M3.1 of table 3.3. It contains alternative regressions for a number of test statistics including F-test for fixed effects, Hausman's test for fixed against random effects, and Kao's Dickery-Fuller test. The second is the results of M4.1 of table 3.4. The third is the results of M5.1 of table 3.5. Appendix A has presented a detailed presentation of the methodologies employed in this appendix. Limdep 8.0 is primarily employed. Most of the results are also checked by other packages such as STATA 8.0 and PC-Give 10.0.

```
? load file chapter3.xls which contains the data
--> RESET
--> Read
    ; File=H:\chapter3\chapter3.xls
    ; Format=xls
    ; Names$

?************************************************************
? Descriptions of variables
? TFP      - index of total factor productivity
? CS       - index of capital stock
? RDD      - index of domestic R&D capital stock
? RDF      - index of foreign R&D capital stock
? Pimports - import share in GDP
? Year     - Time trend
?************************************************************
--> Sample   ; all $
? Luxembourg is excluded due to lack of data
--> Reject   ; IND=8 $
--> Create   ; LKi=log(CS)$
--> Create   ; LTFP=log(TFP)$
--> Create   ; LRDD=log(RDD)$
--> Create   ; LRDF=log(RDF)$
--> Create   ; MRDF=LRDF*Pimports/100$
--> Reject   ; Year<1971 $
--> Reject   ; Year>1990 $
```

```
?*******************************************
? DETAILED RESULTS OF M3.1 FOR ALTERNATIVE REGRESSIONS
?*******************************************
--> Namelist ; X= LRDD, LRDF, MRDF $
--> Namelist ; Y=LTFP $
--> Regress  ; Lhs=Y;
               Rhs=X;
               Str=Ind; Panel; Output=2$

+-----------------------------------------------------------------------+
| OLS Without Group Dummy Variables                                     |
| Ordinary    least squares regression    Weighting variable = none     |
| Dep. var. = LTFP     Mean=  -.5615345911E-01, S.D.=   .9200042734E-01 |
| Model size: Observations =     300, Parameters =   4, Deg.Fr.=    296 |
| Residuals:  Sum of squares= 1.063167884    , Std.Dev.=          .05993 |
| Fit:        R-squared=  .579902, Adjusted R-squared =          .57564 |
| Model test: F[  3,    296] =  136.20,    Prob value =          .00000 |
| Diagnostic: Log-L =    420.6979, Restricted(b=0) Log-L =     290.6079 |
|             LogAmemiyaPrCrt.=   -5.616, Akaike Info. Crt.=     -2.778 |
| Panel Data Analysis of LTFP       [ONE way]                           |
|           Unconditional ANOVA (No regressors)                         |
| Source      Variation        Deg. Free.     Mean Square               |
| Between       .239565              14.         .171118E-01           |
| Residual      2.29119             285.         .803928E-02           |
| Total         2.53076             299.         .846408E-02           |
+-----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |t-ratio |P[|T|>t] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LRDD         .1206619032   .97642011E-02   12.358   .0000    -.25066885
 LRDF      .7535501007E-01  .28801827E-01    2.616   .0093    -.18663357
 MRDF         .1458574726   .78666167E-01    1.854   .0647 -.55191407E-01
 Constant -.3793425087E-02  .44427886E-02    -.854   .3939
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
```

```
+-----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables                              |
| Ordinary    least squares regression    Weighting variable = none     |
| Dep. var. = LTFP     Mean= -.5615345911E-01, S.D.=   .9200042734E-01 |
| Model size: Observations =     300, Parameters =  18, Deg.Fr.=    282 |
| Residuals:  Sum of squares= .6767004711    , Std.Dev.=         .04899 |
| Fit:        R-squared=  .732610, Adjusted R-squared =          .71649 |
| Model test: F[ 17,    282] =   45.45,    Prob value =          .00000 |
| Diagnostic: Log-L =    488.4648, Restricted(b=0) Log-L =     290.6079 |
|             LogAmemiyaPrCrt.=   -5.974, Akaike Info. Crt.=     -3.136 |
| Estd. Autocorrelation of e(i,t)     .775002                           |
+-----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |t-ratio |P[|T|>t] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LRDD          .1195250283   .10245370E-01   11.666   .0000    -.25066885
 LRDF       .8664053015E-01  .29238346E-01    2.963   .0033    -.18663357
 MRDF          .2204871018   .83964323E-01    2.626   .0091 -.55191407E-01
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)


       Estimated Fixed Effects

       Group       Coefficient        Standard Error       t-ratio
           1          -.01269                 .01151      -1.10305
           2          -.04377                 .01103      -3.96794
           3           .04788                 .01307       3.66239
           4          -.00141                 .01140       -.12338
           5          -.02817                 .01121      -2.51286
           6          -.01388                 .01298      -1.06874
           7          -.04523                 .01107      -4.08765
           8           .02990                 .01183       2.52865
           9           .03044                 .01130       2.69316
          10           .09255                 .01317       7.02751
          11          -.01145                 .01124      -1.01895
          12           .02457                 .01122       2.18904
          13          -.02981                 .01141      -2.61224
          14           .01891                 .01247       1.51601
          15          -.02563                 .01143      -2.24220


+------------------------------------------------------------------------+
|              Test Statistics for the Classical Model                   |
|                                                                        |
|        Model              Log-Likelihood    Sum of Squares    R-squared |
| (1)  Constant term only      290.60789    .2530759511D+01     .0000000 |
| (2)  Group effects only      305.52484    .2291194164D+01     .0946614 |
| (3)  X - variables only      420.69786    .1063167884D+01     .5799017 |
| (4)  X and group effects     488.46479    .6767004711D+00     .7326097 |
|                                                                        |
|                              Hypothesis Tests                          |
|              Likelihood Ratio Test                 F Tests             |
|          Chi-squared   d.f.  Prob.          F    num. denom. Prob value |
| (2) vs (1)    29.834     14     .00804     2.129   14   285     .01068 |
| (3) vs (1)   260.180      3     .00000   136.199    3   296     .00000 |
| (4) vs (1)   395.714     17     .00000    45.449   17   282     .00000 |
| (4) vs (2)   365.880      3     .00000   224.268    3   282     .00000 |
| (4) vs (3)   135.534     14     .00000    11.504   14   282     .00000 |
+------------------------------------------------------------------------+
```

```
+-----------------------------------------------------+
| Random Effects Model: v(i,t) = e(i,t) + u(i)         |
| Estimates:  Var[e]              =   .239965D-02      |
|             Var[u]              =   .119214D-02      |
|             Corr[v(i,t),v(i,s)] =   .331907          |
| Lagrange Multiplier Test vs. Model (3) =  282.19     |
| ( 1 df, prob value =  .000000)                        |
| (High values of LM favor FEM/REM over CR model.)      |
| Fixed vs. Random Effects (Hausman)     =    8.59      |
| ( 3 df, prob value =  .035315)                        |
| (High (low) values of H favor FEM (REM).)             |
| Reestimated using GLS coefficients:                   |
| Estimates:  Var[e]              =   .240046D-02      |
|             Var[u]              =   .170737D-02      |
|             Sum of Squares          .107896D+01      |
+-----------------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LRDD	.1202889664	.99280049E-02	12.116	.0000	-.25066885
LRDF	.8581276236E-01	.28516410E-01	3.009	.0026	-.18663357
MRDF	.2080147323	.81334923E-01	2.558	.0105	-.55191407E-01
Constant	.1495405597E-02	.96537804E-02	.155	.8769	

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

```
? ----------------------------------------
? Calculating Kao cointegration tests
? ----------------------------------------

--> Regress ;
            Lhs=Y;
            Rhs= X21;
            Str=Ind;
            Panel;
            Fixed;
            Output=5 $

+----------------------------------------------------------------------+
| OLS Without Group Dummy Variables                                    |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = LTFP     Mean=  -.5615345911E-01, S.D.=   .9200042734E-01 |
| Model size: Observations =     300, Parameters =   4, Deg.Fr.=    296 |
| Residuals:  Sum of squares= 1.063167884     , Std.Dev.=          .05993 |
| Fit:        R-squared=  .579902, Adjusted R-squared =           .57564 |
| Model test: F[  3,     296] =  136.20,     Prob value =          .00000 |
| Diagnostic: Log-L =     420.6979, Restricted(b=0) Log-L =     290.6079 |
|             LogAmemiyaPrCrt.=    -5.616, Akaike Info. Crt.=     -2.778 |
| Panel Data Analysis of LTFP        [ONE way]                         |
|           Unconditional ANOVA (No regressors)                        |
| Source      Variation         Deg. Free.     Mean Square             |
| Between       .239565               14.          .171118E-01         |
| Residual      2.29119              285.          .803928E-02         |
| Total         2.53076              299.          .846408E-02         |
+----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |t-ratio |P[|T|>t] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LRDD          .1206619032   .97642011E-02   12.358   .0000    -.25066885
 LRDF      .7535501007E-01   .28801827E-01    2.616   .0093    -.18663357
 MRDF          .1458574726   .78666167E-01    1.854   .0647 -.55191407E-01
 Constant -.3793425087E-02   .44427886E-02    -.854   .3939
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
```

```
+--------------------------------------------------------------------+
| Least Squares with Group Dummy Variables                            |
| Ordinary    least squares regression    Weighting variable = none   |
| Dep. var. = LTFP     Mean=  -.5615345911E-01, S.D.=    .9200042734E-01 |
| Model size: Observations =     300, Parameters =  18, Deg.Fr.=    282 |
| Residuals:  Sum of squares= .6767004711    , Std.Dev.=         .04899 |
| Fit:        R-squared=  .732610, Adjusted R-squared =          .71649 |
| Model test: F[ 17,    282] =   45.45,    Prob value =          .00000 |
| Diagnostic: Log-L =    488.4648, Restricted(b=0) Log-L =     290.6079 |
|             LogAmemiyaPrCrt.=   -5.974, Akaike Info. Crt.=     -3.136 |
| Estd. Autocorrelation of e(i,t)     .775002                         |
+--------------------------------------------------------------------+
+---------+-------------+---------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |t-ratio |P[|T|>t] | Mean of X|
+---------+-------------+---------------+--------+---------+----------+
LRDD          .1195250283   .10245370E-01   11.666   .0000    -.25066885
LRDF      .8664053015E-01  .29238346E-01    2.963   .0033    -.18663357
MRDF          .2204871018   .83964323E-01    2.626   .0091 -.55191407E-01
(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)


+---------------------------------------------------------------------+
|                Test Statistics for the Classical Model               |
|                                                                     |
|        Model            Log-Likelihood    Sum of Squares    R-squared |
|  (1)  Constant term only      290.60789   .2530759511D+01     .0000000 |
|  (2)  Group effects only      305.52484   .2291194164D+01     .0946614 |
|  (3)  X - variables only      420.69786   .1063167884D+01     .5799017 |
|  (4)  X and group effects     488.46479   .6767004711D+00     .7326097 |
|                                                                     |
|                                Hypothesis Tests                      |
|                Likelihood Ratio Test               F Tests            |
|           Chi-squared   d.f.  Prob.          F    num. denom. Prob value |
|  (2) vs (1)    29.834     14     .00804     2.129   14   285     .01068 |
|  (3) vs (1)   260.180      3     .00000   136.199    3   296     .00000 |
|  (4) vs (1)   395.714     17     .00000    45.449   17   282     .00000 |
|  (4) vs (2)   365.880      3     .00000   224.268    3   282     .00000 |
|  (4) vs (3)   135.534     14     .00000    11.504   14   282     .00000 |
+---------------------------------------------------------------------+
```

```
--> Regress ;
            Lhs=Er;
            Rhs=Er[-1];
            Str=Ind;
            Panel;
            Fixed$

+--------------------------------------------------------------------------+
| OLS Without Group Dummy Variables                                        |
| Ordinary    least squares regression    Weighting variable = none        |
| Dep. var. = ER       Mean=   .2134399861E-02, S.D.=    .4507316622E-01   |
| Model size: Observations =     285, Parameters =   2, Deg.Fr.=    283    |
| Residuals:  Sum of squares= .1596570207    , Std.Dev.=         .02375    |
| Fit:        R-squared=  .723284, Adjusted R-squared =          .72231    |
| Model test: F[  1,     283] =  739.71,    Prob value =         .00000    |
| Diagnostic: Log-L =    662.5309, Restricted(b=0) Log-L =     479.4518   |
|             LogAmemiyaPrCrt.=   -7.473, Akaike Info. Crt.=     -4.635    |
| Panel Data Analysis of ER          [ONE way]                             |
|           Unconditional ANOVA (No regressors)                            |
| Source      Variation        Deg. Free.     Mean Square                  |
| Between       .388219E-02           14.         .277299E-03             |
| Residual      .573089               270.         .212255E-02             |
| Total         .576972               284.         .203159E-02             |
+--------------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |t-ratio |P[|T|>t] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 ER[-1]       .8364134379   .30753177E-01   27.198   .0000 -.11698804E-02
 Constant  .3112903520E-02  .14074089E-02    2.212   .0277
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
```

```
+----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables                             |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = ER       Mean=   .2134399861E-02, S.D.=   .4507316622E-01 |
| Model size: Observations =     285, Parameters =  16, Deg.Fr.=    269 |
| Residuals:  Sum of squares= .1478074786    , Std.Dev.=          .02344 |
| Fit:        R-squared=  .743822, Adjusted R-squared =          .72954 |
| Model test: F[ 15,    269] =   52.07,    Prob value =          .00000 |
| Diagnostic: Log-L =    673.5201, Restricted(b=0) Log-L =     479.4518 |
|             LogAmemiyaPrCrt.=   -7.452, Akaike Info. Crt.=     -4.614 |
| Estd. Autocorrelation of e(i,t)     .172098                          |
+----------------------------------------------------------------------+
+---------+-------------+---------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |t-ratio |P[|T|>t] | Mean of X|
+---------+-------------+---------------+--------+---------+----------+
 ER[-1]       .8470693404   .30447563E-01   27.821   .0000 -.11698804E-02
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

+----------------------------------------------------------------------+
|                Test Statistics for the Classical Model               |
|                                                                      |
|        Model             Log-Likelihood    Sum of Squares    R-squared |
| (1)  Constant term only      479.45183   .5769716490D+00     .0000000 |
| (2)  Group effects only      480.41389   .5730894624D+00     .0067286 |
| (3)  X - variables only      662.53088   .1596570207D+00     .7232845 |
| (4)  X and group effects     673.52009   .1478074786D+00     .7438219 |
|                                                                      |
|                              Hypothesis Tests                        |
|              Likelihood Ratio Test               F Tests             |
|          Chi-squared   d.f.  Prob.           F    num. denom. Prob value |
| (2) vs (1)      1.924     14    .99993      .131    14    270    .99995 |
| (3) vs (1)    366.158      1    .00000   739.711     1    283    .00000 |
| (4) vs (1)    388.137     15    .00000    52.070    15    269    .00000 |
| (4) vs (2)    386.212      1    .00000   773.986     1    269    .00000 |
| (4) vs (3)     21.978     14    .07906     1.540    14    269    .09657 |
+----------------------------------------------------------------------+
```

$$\hat{\gamma} = 0.8471$$

$$t_{\gamma} = \frac{(0.8471-1)\cdot 27.82}{0.8471} = -5.021$$

And thus:

$$DF_{t} = \sqrt{1.25}t_{\gamma} + \sqrt{1.875}N = 14.93 \text{ (Prob value = 0.000)}$$

$$DF_{\gamma} = \frac{\sqrt{N}\left[T(\hat{\gamma}-1)+3\right]}{\sqrt{10.2}} = 2.016. \text{ (Prob value = 0.041)}$$

```
?*********************************************
? DETAILED RESULTS OF M4.1 FOR ALTERNATIVE REGRESSIONS
?*********************************************
```

```
--> Create   ; LTFP1=LTFP[-1]$
--> Create   ; LTFP=log(TFP)$
--> Create   ; LRDD1=LRDD[-1]$
--> Create   ; LRDF1=LRDF[-1]$
--> Reject   ; Year=1971 $


--> Namelist ; X41= LTFP1, LRDD, LRDD1, LRDF, LRDF1, MRDF $
--> Namelist ; Y=LTFP $
--> Regress ;  Lhs=Y;
               Rhs=X41;
               Str=Ind; Panel; Output=2$
```

```
+----------------------------------------------------------------------+
| OLS Without Group Dummy Variables                                    |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = LTFP     Mean= -.4836869860E-01, S.D.=   .8579640572E-01 |
| Model size: Observations =     285, Parameters =   7, Deg.Fr.=   278 |
| Residuals:  Sum of squares= .1072441335    , Std.Dev.=         .01964 |
| Fit:        R-squared=  .948700, Adjusted R-squared =          .94759 |
| Model test: F[  6,    278] =  856.85,    Prob value =          .00000 |
| Diagnostic: Log-L =    719.2345, Restricted(b=0) Log-L =     296.0002 |
|             LogAmemiyaPrCrt.=   -7.836, Akaike Info. Crt.=     -4.998 |
| Panel Data Analysis of LTFP       [ONE way]                          |
|           Unconditional ANOVA (No regressors)                        |
| Source      Variation        Deg. Free.     Mean Square              |
| Between       .194975             14.         .139268E-01            |
| Residual      1.89556            270.         .702058E-02            |
| Total         2.09053            284.         .736102E-02            |
+----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |t-ratio |P[|T|>t] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LTFP1        .9045268279   .20998831E-01   43.075   .0000 -.63260761E-01
 LRDD      .7422564387E-01  .46118099E-01    1.609   .1086    -.22051237
 LRDD1    -.6145011989E-01  .42087295E-01   -1.460   .1454    -.27980596
 LRDF     -.6802018748E-01  .22417529E-01   -3.034   .0026    -.17141184
 LRDF1     .7346726840E-01  .21249882E-01    3.457   .0006    -.20307396
 MRDF     -.3094522851E-02  .27681285E-01    -.112   .9111 -.51893766E-01
 Constant  .1112515626E-01  .31827008E-02    3.496   .0006
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
```

```
+----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables                             |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = LTFP     Mean=  -.4836869860E-01, S.D.=   .8579640572E-01 |
| Model size: Observations =     285, Parameters =  21, Deg.Fr.=    264 |
| Residuals:  Sum of squares= .1006350328    , Std.Dev.=         .01952 |
| Fit:        R-squared=  .951861, Adjusted R-squared =          .94821 |
| Model test: F[ 20,    264] =  261.01,    Prob value =          .00000 |
| Diagnostic: Log-L =    728.2985, Restricted(b=0) Log-L =     296.0002 |
|             LogAmemiyaPrCrt.=   -7.801, Akaike Info. Crt.=     -4.963 |
| Estd. Autocorrelation of e(i,t)    -.018537                          |
+----------------------------------------------------------------------+
+---------+-------------+---------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |t-ratio |P[|T|>t] | Mean of X|
+---------+-------------+---------------+--------+---------+----------+
 LTFP1        .9002229934   .26789214E-01   33.604   .0000 -.63260761E-01
 LRDD         .1018489306   .85017805E-01    1.198   .2319    -.22051237
 LRDD1     -.9340901840E-01  .81606840E-01   -1.145   .2533    -.27980596
 LRDF      -.7678838979E-01  .23636118E-01   -3.249   .0013    -.17141184
 LRDF1      .8062840006E-01  .21982518E-01    3.668   .0003    -.20307396
 MRDF       .4546196977E-01  .35418684E-01    1.284   .2004 -.51893766E-01
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

+----------------------------------------------------------------------+
|                Test Statistics for the Classical Model               |
|                                                                      |
|        Model            Log-Likelihood    Sum of Squares    R-squared |
| (1)  Constant term only      296.00017    .2090530599D+01    .0000000 |
| (2)  Group effects only      309.95174    .1895555957D+01    .0932656 |
| (3)  X - variables only      719.23448    .1072441335D+00    .9487000 |
| (4)  X and group effects     728.29854    .1006350328D+00    .9518615 |
|                                                                      |
|                              Hypothesis Tests                        |
|              Likelihood Ratio Test                  F Tests          |
|          Chi-squared   d.f.  Prob.          F    num. denom. Prob value |
| (2) vs (1)     27.903     14     .01465     1.984   14   270     .01917 |
| (3) vs (1)    846.469      6     .00000   856.851    6   278     .00000 |
| (4) vs (1)    864.597     20     .00000   261.009   20   264     .00000 |
| (4) vs (2)    836.694      6     .00000   784.782    6   264     .00000 |
| (4) vs (3)     18.128     14     .20101     1.238   14   264     .24723 |
+----------------------------------------------------------------------+
```

```
+-----------------------------------------------------+
| Random Effects Model: v(i,t) = e(i,t) + u(i)        |
| Estimates:  Var[e]              =   .381193D-03     |
|             Var[u]              =   .457696D-05     |
|             Corr[v(i,t),v(i,s)] =   .011864         |
| Lagrange Multiplier Test vs. Model (3) =      .18   |
| ( 1 df, prob value =  .669415)                      |
| (High values of LM favor FEM/REM over CR model.)    |
| Fixed vs. Random Effects (Hausman)     =    12.66   |
| ( 6 df, prob value =  .048701)                      |
| (High (low) values of H favor FEM (REM).)           |
| Reestimated using GLS coefficients:                 |
| Estimates:  Var[e]              =   .386683D-03     |
|             Var[u]              =   .138554D-04     |
|             Sum of Squares          .107284D+00     |
+-----------------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LTFP1	.9052136996	.21616139E-01	41.877	.0000	-.63260761E-01
LRDD	.7048482715E-01	.48198993E-01	1.462	.1436	-.22051237
LRDD1	-.5854702069E-01	.44244964E-01	-1.323	.1858	-.27980596
LRDF	-.6909367080E-01	.22472150E-01	-3.075	.0021	-.17141184
LRDF1	.7453060367E-01	.21260298E-01	3.506	.0005	-.20307396
MRDF	.2305658068E-02	.28568215E-01	.081	.9357	-.51893766E-01
Constant	.1146818009E-01	.33379965E-02	3.436	.0006	

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

```
?*******************************************
? DETAILED RESULTS OF M5.1 FOR ALTERNATIVE REGRESSIONS
?*******************************************
```

```
--> Namelist ; X51= LRDD, LRDF, MRDF $
--> Namelist ; Y=LTFP $
--> Regress ;  Lhs=Y;
               Rhs=X51;
               Str=Ind; period=year; Panel; Output=2$
```

```
+--------------------------------------------------------------------+
| OLS Without Group Dummy Variables                                   |
| Ordinary    least squares regression    Weighting variable = none   |
| Dep. var. = LTFP     Mean=  -.5615345911E-01, S.D.=   .9200042734E-01 |
| Model size: Observations =     300, Parameters =   4, Deg.Fr.=    296 |
| Residuals:  Sum of squares= 1.063167884    , Std.Dev.=          .05993 |
| Fit:        R-squared=  .579902, Adjusted R-squared =          .57564 |
| Model test: F[  3,    296] =  136.20,    Prob value =          .00000 |
| Diagnostic: Log-L =    420.6979, Restricted(b=0) Log-L =     290.6079 |
|             LogAmemiyaPrCrt.=   -5.616, Akaike Info. Crt.=     -2.778 |
| Panel Data Analysis of LTFP       [ONE way]                           |
|           Unconditional ANOVA (No regressors)                         |
| Source      Variation        Deg. Free.     Mean Square               |
| Between       .239565              14.         .171118E-01            |
| Residual      2.29119             285.         .803928E-02            |
| Total         2.53076             299.         .846408E-02            |
+--------------------------------------------------------------------+
```

Variable	Coefficient	Standard Error	t-ratio	P[|T|>t]	Mean of X
LRDD	.1206619032	.97642011E-02	12.358	.0000	-.25066885
LRDF	.7535501007E-01	.28801827E-01	2.616	.0093	-.18663357
MRDF	.1458574726	.78666167E-01	1.854	.0647	-.55191407E-01
Constant	-.3793425087E-02	.44427886E-02	-.854	.3939	

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

```
+----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables                             |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = LTFP     Mean= -.5615345911E-01, S.D.=   .9200042734E-01 |
| Model size: Observations =     300, Parameters =  18, Deg.Fr.=    282 |
| Residuals:  Sum of squares= .6767004711    , Std.Dev.=         .04899 |
| Fit:        R-squared=  .732610, Adjusted R-squared =          .71649 |
| Model test: F[ 17,    282] =   45.45,    Prob value =          .00000 |
| Diagnostic: Log-L =    488.4648, Restricted(b=0) Log-L =     290.6079 |
|             LogAmemiyaPrCrt.=   -5.974, Akaike Info. Crt.=     -3.136 |
| Estd. Autocorrelation of e(i,t)      .775002                         |
+----------------------------------------------------------------------+

+---------+-------------+---------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |t-ratio |P[|T|>t] | Mean of X|
+---------+-------------+---------------+--------+---------+----------+
 LRDD         .1195250283   .10245370E-01   11.666   .0000    -.25066885
 LRDF      .8664053015E-01  .29238346E-01    2.963   .0033    -.18663357
 MRDF         .2204871018   .83964323E-01    2.626   .0091 -.55191407E-01
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)


        Estimated Fixed Effects

        Group       Coefficient       Standard Error       t-ratio

            1          -.01269                 .01151      -1.10305
            2          -.04377                 .01103      -3.96794
            3           .04788                 .01307       3.66239
            4          -.00141                 .01140       -.12338
            5          -.02817                 .01121      -2.51286
            6          -.01388                 .01298      -1.06874
            7          -.04523                 .01107      -4.08765
            8           .02990                 .01183       2.52865
            9           .03044                 .01130       2.69316
           10           .09255                 .01317       7.02751
           11          -.01145                 .01124      -1.01895
           12           .02457                 .01122       2.18904
           13          -.02981                 .01141      -2.61224
           14           .01891                 .01247       1.51601
           15          -.02563                 .01143      -2.24220

+-----------------------------------------------------------------------+
|              Test Statistics for the Classical Model                  |
|                                                                       |
|      Model              Log-Likelihood    Sum of Squares    R-squared |
| (1)  Constant term only      290.60789   .2530759511D+01     .0000000 |
| (2)  Group effects only      305.52484   .2291194164D+01     .0946614 |
| (3)  X - variables only      420.69786   .1063167884D+01     .5799017 |
| (4)  X and group effects     488.46479   .6767004711D+00     .7326097 |
|                                                                       |
|                              Hypothesis Tests                         |
|             Likelihood Ratio Test                   F Tests           |
|        Chi-squared   d.f.  Prob.           F    num. denom. Prob value |
| (2) vs (1)    29.834     14     .00804     2.129   14   285     .01068 |
| (3) vs (1)   260.180      3     .00000   136.199    3   296     .00000 |
| (4) vs (1)   395.714     17     .00000    45.449   17   282     .00000 |
| (4) vs (2)   365.880      3     .00000   224.268    3   282     .00000 |
| (4) vs (3)   135.534     14     .00000    11.504   14   282     .00000 |
+-----------------------------------------------------------------------+
```

```
+------------------------------------------------+
| Random Effects Model: v(i,t) = e(i,t) + u(i)    |
| Estimates:  Var[e]              =  .239965D-02  |
|             Var[u]              =  .119214D-02  |
|             Corr[v(i,t),v(i,s)] =  .331907      |
| Lagrange Multiplier Test vs. Model (3) = 282.19 |
| ( 1 df, prob value =  .000000)                  |
| (High values of LM favor FEM/REM over CR model.)|
| Fixed vs. Random Effects (Hausman)     =   8.59 |
| ( 3 df, prob value =  .035315)                  |
| (High (low) values of H favor FEM (REM).)       |
| Reestimated using GLS coefficients:             |
| Estimates:  Var[e]              =  .240046D-02  |
|             Var[u]              =  .170737D-02  |
|             Sum of Squares         .107896D+01  |
+------------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LRDD	.1202889664	.99280049E-02	12.116	.0000	-.25066885
LRDF	.8581276236E-01	.28516410E-01	3.009	.0026	-.18663357
MRDF	.2080147323	.81334923E-01	2.558	.0105	-.55191407E-01
Constant	.1495405597E-02	.96537804E-02	.155	.8769	

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

```
+-----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables and Period Effects           |
| Ordinary    least squares regression    Weighting variable = none     |
| Dep. var. = LTFP     Mean=  -.5615345911E-01, S.D.=   .9200042734E-01 |
| Model size: Observations =      300, Parameters =  37, Deg.Fr.=    263 |
| Residuals:  Sum of squares= .3703159802    , Std.Dev.=          .03752 |
| Fit:        R-squared=  .853674, Adjusted R-squared =           .83364 |
| Model test: F[ 36,    263] =   42.62,    Prob value =           .00000 |
| Diagnostic: Log-L =     578.8956, Restricted(b=0) Log-L =     290.6079 |
|             LogAmemiyaPrCrt.=   -6.449, Akaike Info. Crt.=      -3.613 |
| Estd. Autocorrelation of e(i,t)     .800729                           |
+-----------------------------------------------------------------------+
```

Variable	Coefficient	Standard Error	t-ratio	P[|T|>t]	Mean of X
LRDD	.9502136779E-02	.11079501E-01	.858	.3918	-.25066885
LRDF	-.1334996228	.28559601E-01	-4.674	.0000	-.18663357
MRDF	.2329853707	.66487565E-01	3.504	.0005	-.55191407E-01
Constant	-.6582829072E-01	.59495138E-02	-11.064	.0000	

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

Estimated Fixed Effects - Full sets of effects, normalized to sum to 0

Group	Coefficient	Standard Error	t-ratio
1	.00229	.01106	.20709
2	-.01397	.01116	-1.25127
3	.02477	.01296	1.91170
4	-.01507	.01092	-1.37968
5	-.01087	.01092	-.99526
6	-.03996	.01244	-3.21191
7	-.02293	.01101	-2.08298
8	.04637	.01128	4.11037
9	.01702	.01066	1.59614
10	.04798	.01304	3.68076
11	-.01824	.01065	-1.71254
12	.01763	.01061	1.66063
13	-.01226	.01098	-1.11686
14	.00992	.01199	.82719
15	-.03268	.01096	-2.98203

Estimated Fixed Effects - Full sets of effects, normalized to sum to 0

Period	Coefficient	Standard Error	t-ratio
1	-.16648	.01802	-9.23815
2	-.13418	.01749	-7.67340
3	-.09874	.01684	-5.86412
4	-.09305	.01602	-5.80782
5	-.09855	.01458	-6.75974
6	-.06654	.01379	-4.82650
7	-.05249	.01348	-3.89305
8	-.03345	.01307	-2.55965
9	-.01188	.01270	-.93545
10	.00037	.01244	.02965
11	.00748	.01242	.60231
12	.02250	.01296	1.73534
13	.02882	.01320	2.18347
14	.04787	.01361	3.51748
15	.06583	.01430	4.60470
16	.07866	.01510	5.21100
17	.09319	.01512	6.16185
18	.12023	.01570	7.66027
19	.13961	.01692	8.24929
20	.15079	.01826	8.25842

Test Statistics for the Classical Model

	Model	Log-Likelihood	Sum of Squares	R-squared
(1)	Constant term only	290.60789	.2530759511D+01	.0000000
(2)	Group effects only	305.52484	.2291194164D+01	.0946614
(3)	X - variables only	420.69786	.1063167884D+01	.5799017
(4)	X and group effects	488.46479	.6767004711D+00	.7326097
(5)	X ind.&time effects	578.89561	.3703159802D+00	.8536740

Hypothesis Tests

	Likelihood Ratio Test			F Tests			
	Chi-squared	d.f.	Prob.	F	num.	denom.	Prob value
(2) vs (1)	29.834	14	.00804	2.129	14	285	.01068
(3) vs (1)	260.180	3	.00000	136.199	3	296	.00000
(4) vs (1)	395.714	17	.00000	45.449	17	282	.00000
(4) vs (2)	365.880	3	.00000	224.268	3	282	.00000
(4) vs (3)	135.534	14	.00000	11.504	14	282	.00000
(5) vs (4)	180.862	19	.00000	11.452	19	263	.00000
(5) vs (3)	316.395	34	.00000	14.473	34	263	.00000

```
+--------------------------------------------------------+
| Random Effects Model: v(i,t) = e(i,t) + u(i) + w(t)      |
| Estimates:  Var[e]              =   .140805D-02          |
|             Var[u]              =   .665593D-03          |
|             Corr[v(i,t),v(i,s)] =   .320978              |
|             Var[w]              =   .809280D-02          |
|             Corr[v(i,t),v(j,t)] =   .851798              |
| Lagrange Multiplier Test vs. Model (3) =  287.86         |
| ( 2 df, prob value =  .000000)                           |
| (High values of LM favor FEM/REM over CR model.)         |
| Fixed vs. Random Effects (Hausman)     =    8.54         |
| ( 3 df, prob value =  .036145)                           |
| (High (low) values of H favor FEM (REM).)                |
| Reestimated using GLS coefficients:                      |
| Estimates:  Var[e]              =   .141353D-02          |
|             Var[u]              =   .866018D-03          |
|             Var[w]              =   .918021D-02          |
|             Sum of Squares          .268231D+01          |
+--------------------------------------------------------+
+---------+--------------+---------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+---------------+--------+---------+----------+
 LRDD      .1901884280E-01  .10520684E-01    1.808   .0706    -.25066885
 LRDF       -.1161309478    .27317395E-01   -4.251   .0000    -.18663357
 MRDF        .2268365425    .64116155E-01    3.538   .0004 -.55191407E-01
 Constant -.6054053360E-01  .21913023E-01   -2.763   .0057
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
```

APPENDIX M

SOME DETAILED RESULTS OF REGRESSIONS AND TESTS FOR CHAPTER 4

This appendix contains three examples of more detailed results of regressions and tests for chapter four. The first example is the results of M2.1 of table 4.2. It contains alternative regressions for a number of test statistics including F-test for fixed effects, Hausman's test for fixed against random effects, Ramsey reset test, Hausman's test for exogoneity. The second is the results of M2.6 of table 4.2. It contains regressions for a two-stage instrumental variable LSDV. Appendix A has presented a detailed presentation of the methodologies employed in this appendix. Limdep 8.0 is primarily employed. Most of the results are also checked by other packages such as STATA 8.0 and PC-Give 10.0. 0.

```
? load file chapter401.xls which contains the annual data

--> RESET
--> Read
    ; File=H:\chapter4\chapter401.xls
    ; Format=xls
    ; Names$

?************************************************************
? Descriptions of variables
? RGDP      - real GDP growth rate
? LGDPea    - log one year lagged per capita GDP
? Inflat    - inflation rate
? RGDINV    - investment ratio in GDP
? GGC       - general government consumption ratio
? Ptrade    - Openness (total trade/GDP)
? Life      - Life expectancy
? Rfert     - Fertility rate
? Purban    - Urbanisation
?************************************************************
```

```
?*******************************************
? DETAILED RESULTS OF M2.1 FOR ALTERNATIVE REGRESSIONS
?*******************************************
--> Namelist ; X21=LGDPea,INflat,RGDINV,GGC,PTrade,life,RFert,PUrban$
--> Namelist ; Y=RGDP $

--> Regress ;  Lhs=Y;
               Rhs= X21;
               Str=Ind;
               Period=period;
               Panel;
               Output=2$

+----------------------------------------------------------------------+
| OLS Without Group Dummy Variables                                    |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = RGDP     Mean=   2.990571385    , S.D.=   2.776706705    |
| Model size: Observations =     592, Parameters =   9, Deg.Fr.=   583 |
| Residuals:  Sum of squares= 2663.672951    , Std.Dev.=       2.13750 |
| Fit:        R-squared=  .415434, Adjusted R-squared =         .40741 |
| Model test: F[  8,    583] =   51.79,    Prob value =         .00000 |
| Diagnostic: Log-L =  -1285.1822, Restricted(b=0) Log-L =  -1444.1004 |
|             LogAmemiyaPrCrt.=    1.534, Akaike Info. Crt.=     4.372 |
| Panel Data Analysis of RGDP       [ONE way]                          |
|           Unconditional ANOVA (No regressors)                        |
| Source      Variation        Deg. Free.     Mean Square              |
| Between       341.921              15.         22.7947               |
| Residual      4214.75             576.         7.31727               |
| Total         4556.67             591.         7.71010               |
+----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDPEA      -2.449483733       .32844211    -7.458   .0000     9.6406244
 INFLAT      -.2483111250    .18873368E-01  -13.157   .0000     6.7213334
 RGDINV       .2438608964    .24712502E-01    9.868   .0000     23.466047
 GGC       -.1297450107E-01  .25121064E-01    -.516   .6055     16.038649
 PTRADE     .6402982054E-02  .24749249E-02    2.587   .0097     63.618074
 LIFE        -5.348036199      3.6938430     -1.448   .1477     4.2984729
 RFERT       -.6653030312      .22364224     -2.975   .0029     2.0418395
 PURBAN     .1163953114E-01  .80175873E-02    1.452   .1466     70.659797
 Constant     45.87678644      15.376766      2.984   .0028
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
```

```
+----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables                             |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = RGDP     Mean=   2.990571385     , S.D.=   2.776706705   |
| Model size: Observations =     592, Parameters =  24, Deg.Fr.=   568 |
| Residuals:  Sum of squares= 2248.727186     , Std.Dev.=      1.98973 |
| Fit:        R-squared=  .506498, Adjusted R-squared =         .48651 |
| Model test: F[ 23,    568] =   25.35,    Prob value =         .00000 |
| Diagnostic: Log-L =  -1235.0571, Restricted(b=0) Log-L =  -1444.1004 |
|             LogAmemiyaPrCrt.=    1.416, Akaike Info. Crt.=     4.254 |
| Estd. Autocorrelation of e(i,t)     .181873                          |
+----------------------------------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LGDPEA	-3.555682209	.97508986	-3.647	.0003	9.6406244
INFLAT	-.2649612738	.20104663E-01	-13.179	.0000	6.7213334
RGDINV	.2774689353	.33653876E-01	8.245	.0000	23.466047
GGC	-.1949579283	.57640837E-01	-3.382	.0007	16.038649
PTRADE	.7585991622E-01	.11885495E-01	6.383	.0000	63.618074
LIFE	-14.36178299	8.6056627	-1.669	.0951	4.2984729
RFERT	-1.365846696	.31654778	-4.315	.0000	2.0418395
PURBAN	.4288927618E-01	.29072652E-01	1.475	.1401	70.659797

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

Estimated Fixed Effects

Group	Coefficient	Standard Error	t-ratio
1	87.81053	29.54261	2.97233
2	93.86353	29.65043	3.16567
3	92.97032	30.54122	3.04409
4	93.46547	30.34019	3.08058
5	94.92613	29.86382	3.17863
6	91.42218	30.28328	3.01890
7	93.80985	30.12932	3.11357
8	83.57510	29.31578	2.85086
9	88.87774	29.84955	2.97752
10	91.53721	29.72317	3.07966
11	91.64277	30.42803	3.01179
12	93.58680	29.84579	3.13568
13	95.08546	29.96230	3.17350
14	93.61150	29.88016	3.13290
15	96.85180	29.65591	3.26585
16	94.27865	29.83869	3.15961

```
+----------------------------------------------------------------------+
|                Test Statistics for the Classical Model               |
|                                                                      |
|       Model              Log-Likelihood    Sum of Squares   R-squared |
| (1)  Constant term only   -1444.10042   .4556669174D+04    .0000000 |
| (2)  Group effects only   -1421.01183   .4214748526D+04    .0750374 |
| (3)  X - variables only   -1285.18218   .2663672951D+04    .4154342 |
| (4)  X and group effects  -1235.05706   .2248727186D+04    .5064976 |
|                                                                      |
|                              Hypothesis Tests                        |
|              Likelihood Ratio Test                 F Tests            |
|         Chi-squared   d.f.  Prob.          F    num. denom. Prob value |
| (2) vs (1)    46.177    15    .00005     3.115   15   576     .00007 |
| (3) vs (1)   317.836     8    .00000    51.790    8   583     .00000 |
| (4) vs (1)   418.087    23    .00000    25.346   23   568     .00000 |
| (4) vs (2)   371.910     8    .00000    62.074    8   568     .00000 |
| (4) vs (3)   100.250    15    .00000     6.987   15   568     .00000 |
+----------------------------------------------------------------------+
```

```
+----------------------------------------------------+
| Random Effects Model: v(i,t) = e(i,t) + u(i)        |
| Estimates:  Var[e]              =   .395903D+01     |
|             Var[u]              =   .609881D+00     |
|             Corr[v(i,t),v(i,s)] =   .133485         |
| Lagrange Multiplier Test vs. Model (3) =    9.36    |
| ( 1 df, prob value =  .002214)                      |
| (High values of LM favor FEM/REM over CR model.)    |
| Fixed vs. Random Effects (Hausman)      =   51.28   |
| ( 8 df, prob value =  .000000)                      |
| (High (low) values of H favor FEM (REM).)           |
| Reestimated using GLS coefficients:                 |
| Estimates:  Var[e]              =   .417928D+01     |
|             Var[u]              =   .198056D+01     |
|             Sum of Squares          .291605D+04     |
+----------------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LGDPEA	-3.159206152	.58158045	-5.432	.0000	9.6406244
INFLAT	-.2607268816	.18812458E-01	-13.859	.0000	6.7213334
RGDINV	.2904142856	.29805302E-01	9.744	.0000	23.466047
GGC	-.6589664085E-01	.41381761E-01	-1.592	.1113	16.038649
PTRADE	.1725579959E-01	.51342605E-02	3.361	.0008	63.618074
LIFE	-8.053903244	5.3350180	-1.510	.1311	4.2984729
RFERT	-1.491588608	.27174904	-5.489	.0000	2.0418395
PURBAN	.2250346798E-01	.15408314E-01	1.460	.1442	70.659797
Constant	64.41893954	20.315769	3.171	.0015	

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

```
+----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables and Period Effects           |
| Ordinary    least squares regression    Weighting variable = none     |
| Dep. var. = RGDP     Mean=   2.990571385    , S.D.=   2.776706705     |
| Model size: Observations =     592, Parameters =  60, Deg.Fr.=    532 |
| Residuals:  Sum of squares= 1647.259187    , Std.Dev.=       1.75965 |
| Fit:        R-squared=  .638495, Adjusted R-squared =          .59840 |
| Model test: F[ 59,    532] =    15.93,    Prob value =         .00000 |
| Diagnostic: Log-L =  -1142.9266, Restricted(b=0) Log-L =   -1444.1004 |
|             LogAmemiyaPrCrt.=    1.227, Akaike Info. Crt.=      4.064 |
| Estd. Autocorrelation of e(i,t)     .149392                           |
+----------------------------------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LGDPEA	-6.646670285	1.1297053	-5.884	.0000	9.6406244
INFLAT	-.1958215078	.25117868E-01	-7.796	.0000	6.7213334
RGDINV	.2479156484	.32447375E-01	7.641	.0000	23.466047
GGC	-.2272072550	.58072038E-01	-3.913	.0001	16.038649
PTRADE	.7291183614E-01	.11941658E-01	6.106	.0000	63.618074
LIFE	-21.67610215	9.5784597	-2.263	.0236	4.2984729
RFERT	-.8161197750	.30241641	-2.699	.0070	2.0418395
PURBAN	.5500945027E-01	.26692381E-01	2.061	.0393	70.659797
Constant	152.5263580	36.383562	4.192	.0000	

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

Estimated Fixed Effects - Full sets of effects, normalized to sum to 0

Group	Coefficient	Standard Error	t-ratio
1	-3.95781	1.04875	-3.77385
2	3.25442	.77634	4.19200
3	-1.70257	1.08100	-1.57499
4	-.70933	.89492	-.79262
5	3.24930	.53261	6.10068
6	-2.93103	1.05043	-2.79031
7	.88354	.55039	1.60529
8	-7.06320	1.66966	-4.23032
9	-2.64980	.70590	-3.75380
10	.27597	.58644	.47059
11	-3.86705	1.26629	-3.05384
12	1.91897	.69518	2.76040
13	4.03433	.71136	5.67133
14	.58634	.70505	.83164
15	5.13804	.86716	5.92513
16	3.53986	.97839	3.61803

Estimated Fixed Effects - Full sets of effects, normalized to sum to 0

Period	Coefficient	Standard Error	t-ratio
1	-2.86450	.91762	-3.12165
2	-3.50266	.87280	-4.01312
3	-2.64237	.83813	-3.15270
4	-1.29823	.81933	-1.58450
5	-2.75126	.77647	-3.54327
6	-2.71142	.73942	-3.66694
7	-1.91910	.70937	-2.70537
8	-.42463	.67989	-.62456
9	.43477	.65586	.66291
10	-.82014	.62679	-1.30847
11	-1.48118	.59579	-2.48608
12	.64467	.58534	1.10135
13	1.37425	.58012	2.36890
14	-1.82807	.60742	-3.00958
15	-2.57105	.56940	-4.51535
16	.80790	.54072	1.49412
17	.09064	.53854	.16831
18	.34587	.51938	.66594
19	.66290	.52841	1.25452
20	-.12618	.56120	-.22484
21	-1.18662	.57017	-2.08116
22	-.17198	.56549	-.30412
23	.12792	.56849	.22501
24	.95208	.58502	1.62743
25	.80467	.59785	1.34596
26	1.16730	.58803	1.98509
27	1.24363	.60416	2.05845
28	2.69854	.61161	4.41221
29	2.29978	.62716	3.66695
30	1.38647	.64277	2.15701
31	.28794	.66571	.43254
32	.62461	.68873	.90689
33	.26554	.71164	.37313
34	2.75838	.72039	3.82902
35	2.47238	.73863	3.34726
36	2.24294	.76361	2.93728
37	2.60621	.78664	3.31310

```
+--------------------------------------------------------------------+
|                Test Statistics for the Classical Model             |
|                                                                    |
|       Model              Log-Likelihood    Sum of Squares    R-squared |
| (1)  Constant term only     -1444.10042   .4556669174D+04     .0000000 |
| (2)  Group effects only     -1421.01183   .4214748526D+04     .0750374 |
| (3)  X - variables only     -1285.18218   .2663672951D+04     .4154342 |
| (4)  X and group effects    -1235.05706   .2248727186D+04     .5064976 |
| (5)  X ind.&time effects    -1142.92660   .1647259187D+04     .6384949 |
|                                                                    |
|                            Hypothesis Tests                        |
|              Likelihood Ratio Test              F Tests            |
|         Chi-squared   d.f.   Prob.          F    num. denom. Prob value |
| (2) vs (1)     46.177     15     .00005     3.115   15   576      .00007 |
| (3) vs (1)    317.836      8     .00000    51.790    8   583      .00000 |
| (4) vs (1)    418.087     23     .00000    25.346   23   568      .00000 |
| (4) vs (2)    371.910      8     .00000    62.074    8   568      .00000 |
| (4) vs (3)    100.250     15     .00000     6.987   15   568      .00000 |
| (5) vs (4)    184.261     36     .00000     5.396   36   532      .00000 |
| (5) vs (3)    284.511     52     .00000     6.313   52   532      .00000 |
+--------------------------------------------------------------------+

            +------------------------------------------------------+
            | Random Effects Model: v(i,t) = e(i,t) + u(i) + w(t)  |
            | Estimates:  Var[e]              =   .309635D+01      |
            |             Var[u]              =   .112975D+02      |
            |             Corr[v(i,t),v(i,s)] =   .784883          |
            |             Var[w]              =   .299925D+01      |
            |             Corr[v(i,t),v(j,t)] =   .492035          |
            | Lagrange Multiplier Test vs. Model (3) =  138.42     |
            | ( 2 df, prob value =  .000000)                       |
            | (High values of LM favor FEM/REM over CR model.)     |
            | Fixed vs. Random Effects (Hausman)     =   23.04     |
            | ( 8 df, prob value =  .003316)                       |
            | (High (low) values of H favor FEM (REM).)            |
            | Reestimated using GLS coefficients:                  |
            | Estimates:  Var[e]              =   .314350D+01      |
            |             Var[u]              =   .161744D+02      |
            |             Var[w]              =   .169041D+01      |
            |             Sum of Squares          .668085D+04      |
            +------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDPEA      -4.993785031       .96492098    -5.175    .0000    9.6406244
 INFLAT      -.2055280218    .24000745E-01   -8.563    .0000    6.7213334
 RGDINV       .2445817074    .31456499E-01    7.775    .0000    23.466047
 GGC         -.1647988190    .53398157E-01   -3.086    .0020    16.038649
 PTRADE    .6286005327E-01   .10279445E-01    6.115    .0000    63.618074
 LIFE        -14.29606239       8.5737052    -1.667    .0954    4.2984729
 RFERT       -1.117460719       .29041752    -3.848    .0001    2.0418395
 PURBAN    .3962675492E-01   .24598568E-01    1.611    .1072    70.659797
 Constant     106.3528423       31.385619     3.389    .0007
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
```

```
? -----------------------------------------------------------------
? Calculating Akaike information criterion (AIC), Schwarz
? Bayesian information criterion (SBIC), and Ramsey RESET test
? -----------------------------------------------------------------

--> Regress ;
              Lhs=Y;
              Rhs= X21;
              Str=Ind;
              Period=period;
              Panel;
              Fixed;
              Keep=YH $

+--------------------------------------------------------------------+
| OLS Without Group Dummy Variables                                  |
| Ordinary    least squares regression    Weighting variable = none  |
| Dep. var. = RGDP     Mean=   2.990571385    , S.D.=   2.776706705  |
| Model size: Observations =     592, Parameters =   9, Deg.Fr.=  583 |
| Residuals:  Sum of squares= 2663.672951    , Std.Dev.=      2.13750 |
| Fit:        R-squared=  .415434, Adjusted R-squared =        .40741 |
| Model test: F[  8,    583] =   51.79,    Prob value =        .00000 |
| Diagnostic: Log-L =  -1285.1822, Restricted(b=0) Log-L =  -1444.1004 |
|             LogAmemiyaPrCrt.=    1.534, Akaike Info. Crt.=     4.372 |
| Panel Data Analysis of RGDP       [ONE way]                         |
|           Unconditional ANOVA (No regressors)                      |
| Source      Variation        Deg. Free.     Mean Square           |
| Between       341.921              15.         22.7947            |
| Residual      4214.75             576.         7.31727            |
| Total         4556.67             591.         7.71010            |
+--------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDPEA      -2.449483733      .32844211    -7.458   .0000     9.6406244
 INFLAT      -.2483111250   .18873368E-01  -13.157   .0000     6.7213334
 RGDINV       .2438608964   .24712502E-01    9.868   .0000     23.466047
 GGC       -.1297450107E-01 .25121064E-01   -.516    .6055     16.038649
 PTRADE     .6402982054E-02 .24749249E-02    2.587   .0097     63.618074
 LIFE        -5.348036199      3.6938430    -1.448   .1477     4.2984729
 RFERT       -.6653030312      .22364224    -2.975   .0029     2.0418395
 PURBAN     .1163953114E-01 .80175873E-02    1.452   .1466     70.659797
 Constant     45.87678644      15.376766     2.984   .0028
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
```

Least Squares with Group Dummy Variables
Ordinary least squares regression Weighting variable = none
Dep. var. = RGDP Mean= 2.990571385 , S.D.= 2.776706705
Model size: Observations = 592, Parameters = 24, Deg.Fr.= 568
Residuals: Sum of squares= 2248.727186 , Std.Dev.= 1.98973
Fit: R-squared= .506498, Adjusted R-squared = .48651
Model test: F[23, 568] = 25.35, Prob value = .00000
Diagnostic: Log-L = -1235.0571, Restricted(b=0) Log-L = -1444.1004
LogAmemiyaPrCrt.= 1.416, Akaike Info. Crt.= 4.254
Estd. Autocorrelation of e(i,t) .181873

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LGDPEA	-3.555682209	.97508986	-3.647	.0003	9.6406244
INFLAT	-.2649612738	.20104663E-01	-13.179	.0000	6.7213334
RGDINV	.2774689353	.33653876E-01	8.245	.0000	23.466047
GGC	-.1949579283	.57640837E-01	-3.382	.0007	16.038649
PTRADE	.7585991622E-01	.11885495E-01	6.383	.0000	63.618074
LIFE	-14.36178299	8.6056627	-1.669	.0951	4.2984729
RFERT	-1.365846696	.31654778	-4.315	.0000	2.0418395
PURBAN	.4288927618E-01	.29072652E-01	1.475	.1401	70.659797

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

Test Statistics for the Classical Model

	Model	Log-Likelihood	Sum of Squares	R-squared
(1)	Constant term only	-1444.10042	.4556669174D+04	.0000000
(2)	Group effects only	-1421.01183	.4214748526D+04	.0750374
(3)	X - variables only	-1285.18218	.2663672951D+04	.4154342
(4)	X and group effects	-1235.05706	.2248727186D+04	.5064976

Hypothesis Tests

	Likelihood Ratio Test			F Tests			
	Chi-squared	d.f.	Prob.	F	num.	denom.	Prob value
(2) vs (1)	46.177	15	.00005	3.115	15	576	.00007
(3) vs (1)	317.836	8	.00000	51.790	8	583	.00000
(4) vs (1)	418.087	23	.00000	25.346	23	568	.00000
(4) vs (2)	371.910	8	.00000	62.074	8	568	.00000
(4) vs (3)	100.250	15	.00000	6.987	15	568	.00000

```
+-------------------------------------------------------------------+
| Least Squares with Group Dummy Variables and Period Effects       |
| Ordinary    least squares regression    Weighting variable = none |
| Dep. var. = RGDP     Mean=   2.990571385    , S.D.=    2.776706705 |
| Model size: Observations =     592, Parameters =  60, Deg.Fr.=    532 |
| Residuals:  Sum of squares= 1647.259187    , Std.Dev.=        1.75965 |
| Fit:        R-squared=  .638495, Adjusted R-squared =          .59840 |
| Model test: F[ 59,    532] =   15.93,     Prob value =         .00000 |
| Diagnostic: Log-L =  -1142.9266, Restricted(b=0) Log-L =   -1444.1004 |
|             LogAmemiyaPrCrt.=    1.227, Akaike Info. Crt.=      4.064 |
| Estd. Autocorrelation of e(i,t)      .149392                      |
+-------------------------------------------------------------------+
+---------+-------------+---------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+-------------+---------------+--------+---------+----------+
 LGDPEA      -6.646670285       1.1297053   -5.884   .0000     9.6406244
 INFLAT      -.1958215078   .25117868E-01   -7.796   .0000     6.7213334
 RGDINV       .2479156484   .32447375E-01    7.641   .0000     23.466047
 GGC         -.2272072550   .58072038E-01   -3.913   .0001     16.038649
 PTRADE    .7291183614E-01  .11941658E-01    6.106   .0000     63.618074
 LIFE        -21.67610215       9.5784597   -2.263   .0236     4.2984729
 RFERT       -.8161197750        .30241641   -2.699   .0070     2.0418395
 PURBAN    .5500945027E-01  .26692381E-01    2.061   .0393     70.659797
 Constant     152.5263580       36.383562    4.192   .0000
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

+--------------------------------------------------------------------+
|                Test Statistics for the Classical Model             |
|                                                                    |
|         Model              Log-Likelihood    Sum of Squares    R-squared |
| (1)   Constant term only      -1444.10042    .4556669174D+04     .0000000 |
| (2)   Group effects only      -1421.01183    .4214748526D+04     .0750374 |
| (3)   X - variables only      -1285.18218    .2663672951D+04     .4154342 |
| (4)   X and group effects     -1235.05706    .2248727186D+04     .5064976 |
| (5)   X ind.&time effects     -1142.92660    .1647259187D+04     .6384949 |
|                                                                    |
|                               Hypothesis Tests                     |
|               Likelihood Ratio Test                 F Tests        |
|          Chi-squared   d.f.   Prob.          F     num. denom. Prob value |
| (2) vs (1)    46.177     15      .00005      3.115    15    576      .00007 |
| (3) vs (1)   317.836      8      .00000     51.790     8    583      .00000 |
| (4) vs (1)   418.087     23      .00000     25.346    23    568      .00000 |
| (4) vs (2)   371.910      8      .00000     62.074     8    568      .00000 |
| (4) vs (3)   100.250     15      .00000      6.987    15    568      .00000 |
| (5) vs (4)   184.261     36      .00000      5.396    36    532      .00000 |
| (5) vs (3)   284.511     52      .00000      6.313    52    532      .00000 |
+--------------------------------------------------------------------+

? Calculating Bayesian information criterion (SBIC)

--> Calc; list; SBIC=(-2/Nreg)*(LogL-(Kreg+1)*(0.5)*log(Nreg))$
    SBIC     =  .45082155455808750D+01

? Calculating Akaike information criterion (AIC)

--> Calc; list; AIC=(-2/Nreg)*(LogL-Kreg-1)$
    AIC      =  .40639412244777670D+01

--> Calc; list; LL0=LogL$
    LL0      = -.11429266024454190D+04

> Create; YH2=YH*YH $
```

```
--> Regress;
          Lhs=Y;
          Rhs= X21, YH2;
          Str=Ind;
          Period=period;
          Panel;
          Fixed $
```

```
+----------------------------------------------------------------------+
| OLS Without Group Dummy Variables                                    |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = RGDP     Mean=   2.990571385    , S.D.=   2.776706705    |
| Model size: Observations =     592, Parameters =  10, Deg.Fr.=    582 |
| Residuals:  Sum of squares= 2090.365547    , Std.Dev.=        1.89518 |
| Fit:        R-squared=  .541251, Adjusted R-squared =          .53416 |
| Model test: F[  9,    582] =   76.30,    Prob value =          .00000 |
| Diagnostic: Log-L =  -1213.4416, Restricted(b=0) Log-L =   -1444.1004 |
|             LogAmemiyaPrCrt.=    1.295, Akaike Info. Crt.=      4.133 |
| Panel Data Analysis of RGDP       [ONE way]                          |
|           Unconditional ANOVA (No regressors)                        |
| Source      Variation        Deg. Free.     Mean Square              |
| Between       341.921             15.         22.7947                |
| Residual      4214.75            576.         7.31727                |
| Total         4556.67            591.         7.71010                |
+----------------------------------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LGDPEA	-.7380760846	.32117124	-2.298	.0216	9.6406244
INFLAT	-.1083398671	.20068852E-01	-5.398	.0000	6.7213334
RGDINV	.9183406357E-01	.24997640E-01	3.674	.0002	23.466047
GGC	-.9134312257E-02	.22275216E-01	-.410	.6818	16.038649
PTRADE	.4795958663E-02	.21980314E-02	2.182	.0291	63.618074
LIFE	1.744986931	3.3228510	.525	.5995	4.2984729
RFERT	.3556574852E-01	.20590215	.173	.8629	2.0418395
PURBAN	.4234405092E-02	.71327729E-02	.594	.5527	70.659797
YH2	.9010618116E-01	.71319852E-02	12.634	.0000	13.858061
Constant	-.6006138559	14.121130	-.043	.9661	

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

```
+----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables                             |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = RGDP     Mean=   2.990571385    , S.D.=    2.776706705   |
| Model size: Observations =     592, Parameters =  25, Deg.Fr.=    567 |
| Residuals:  Sum of squares= 1983.116723    , Std.Dev.=       1.87018 |
| Fit:        R-squared=  .564788, Adjusted R-squared =         .54637 |
| Model test: F[ 24,    567] =   30.66,    Prob value =         .00000 |
| Diagnostic: Log-L =  -1197.8515, Restricted(b=0) Log-L =  -1444.1004 |
|             LogAmemiyaPrCrt.=    1.293, Akaike Info. Crt.=     4.131 |
| Estd. Autocorrelation of e(i,t)     .160797                          |
+----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDPEA      -1.224615353        .95473960    -1.283   .1996    9.6406244
 INFLAT      -.1362392125   .23984777E-01    -5.680   .0000    6.7213334
 RGDINV       .1474758301   .34972625E-01     4.217   .0000    23.466047
 GGC         -.1682350803   .54264178E-01    -3.100   .0019    16.038649
 PTRADE    .2843827362E-01  .12426240E-01     2.289   .0221    63.618074
 LIFE        -1.540143249       8.2213139     -.187   .8514    4.2984729
 RFERT       -.5217806595        .31289671    -1.668   .0954    2.0418395
 PURBAN    .3618731492E-01  .27336630E-01     1.324   .1856    70.659797
 YH2       .7683579347E-01  .88170560E-02     8.714   .0000    13.858061
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

+----------------------------------------------------------------------+
|              Test Statistics for the Classical Model                 |
|                                                                      |
|       Model              Log-Likelihood    Sum of Squares   R-squared |
| (1)   Constant term only     -1444.10042   .4556669174D+04    .0000000 |
| (2)   Group effects only     -1421.01183   .4214748526D+04    .0750374 |
| (3)   X - variables only     -1213.44154   .2090365547D+04    .5412514 |
| (4)   X and group effects    -1197.85145   .1983116723D+04    .5647881 |
|                                                                      |
|                            Hypothesis Tests                          |
|              Likelihood Ratio Test                  F Tests          |
|           Chi-squared   d.f.   Prob.          F    num. denom. Prob value |
| (2) vs (1)     46.177     15     .00005      3.115   15   576     .00007 |
| (3) vs (1)    461.318      9     .00000     76.297    9   582     .00000 |
| (4) vs (1)    492.498     24     .00000     30.659   24   567     .00000 |
| (4) vs (2)    446.321      9     .00000     70.895    9   567     .00000 |
| (4) vs (3)     31.180     15     .00831      2.044   15   567     .01121 |
+----------------------------------------------------------------------+
```

```
+---------------------------------------------------------------------+
| Least Squares with Group Dummy Variables and Period Effects         |
| Ordinary    least squares regression    Weighting variable = none   |
| Dep. var. = RGDP     Mean=   2.990571385    , S.D.=   2.776706705   |
| Model size: Observations =     592, Parameters =  61, Deg.Fr.=   531 |
| Residuals:  Sum of squares= 1647.216131    , Std.Dev.=       1.76128 |
| Fit:        R-squared=  .638504, Adjusted R-squared =         .59766 |
| Model test: F[ 60,    531] =   15.63,    Prob value =         .00000 |
| Diagnostic: Log-L =  -1142.9189, Restricted(b=0) Log-L =  -1444.1004 |
|             LogAmemiyaPrCrt.=    1.230, Akaike Info. Crt.=     4.067 |
| Estd. Autocorrelation of e(i,t)     .149870                         |
+---------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDPEA      -6.757286358       1.4697586   -4.598   .0000     9.6406244
 INFLAT      -.1977144273   .29836909E-01   -6.627   .0000     6.7213334
 RGDINV       .2507738345   .40538532E-01    6.186   .0000     23.466047
 GGC         -.2284418192   .59062998E-01   -3.868   .0001     16.038649
 PTRADE    .7398972135E-01  .15052483E-01    4.915   .0000     63.618074
 LIFE        -22.10156705       10.244980   -2.157   .0310     4.2984729
 RFERT       -.8283323309       .31995530   -2.589   .0096     2.0418395
 PURBAN    .5544276821E-01  .26969141E-01    2.056   .0398     70.659797
 YH2      -.1702471916E-02  .14450875E-01    -.118   .9062     13.858061
 Constant     155.3364066       43.533299    3.568   .0004
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

+----------------------------------------------------------------------+
|                 Test Statistics for the Classical Model              |
|                                                                      |
|        Model             Log-Likelihood    Sum of Squares    R-squared |
| (1)  Constant term only    -1444.10042   .4556669174D+04     .0000000 |
| (2)  Group effects only    -1421.01183   .4214748526D+04     .0750374 |
| (3)  X - variables only    -1213.44154   .2090365547D+04     .5412514 |
| (4)  X and group effects   -1197.85145   .1983116723D+04     .5647881 |
| (5)  X ind.&time effects   -1142.91887   .1647216131D+04     .6385043 |
|                                                                      |
|                              Hypothesis Tests                        |
|                Likelihood Ratio Test               F Tests           |
|           Chi-squared   d.f.  Prob.          F    num. denom. Prob value |
| (2) vs (1)    46.177     15     .00005     3.115   15   576     .00007 |
| (3) vs (1)   461.318      9     .00000    76.297    9   582     .00000 |
| (4) vs (1)   492.498     24     .00000    30.659   24   567     .00000 |
| (4) vs (2)   446.321      9     .00000    70.895    9   567     .00000 |
| (4) vs (3)    31.180     15     .00831     2.044   15   567     .01121 |
| (5) vs (4)   109.865     36     .00000     3.008   36   531     .00000 |
| (5) vs (3)   141.045     52     .00000     2.747   52   531     .00000 |

--> Calc; list; LL1=LogL$
    LL1     = -.11429188656134920D+04
```

? Calculating the Ramsey RESET test statistic (Log likelihood test)

```
--> Calc; list; LR=2*(LL1-LL0)$
    LR      =  .16473663853754260D-01
--> Calc; list; Prob=1-chi(LR, 1)$
    PROB    =  .68400397093130270D+00
```

```
? ------------------------------------------------------------
? Calculating Durbin-Wu-Hausman test statistics
? ------------------------------------------------------------

--> Sample; all$
--> Create; LLGDPea=LGDPea[-1]
          ; LInflat=inflat[-1]
          ; LRGDINV=RGDINV[-1]
          ; LGGC=GGC[-1]
          ; Ltrade=ptrade[-1]
          ; Llife=life[-1]
          ; LRfert=Rfert[-1]
          ; Lurban=purban[-1] $

--> Namelist; IV=LGDPea, Ptrade, Life, Rfert, Linflat, LRGDINV, LGGC,
                LTrade, Llife, LRfert, Lurban $
--> Reject  ; period=1$
```

```
? -----------------------------------------------------------------------
? Durbin-Wu-Hausman test statistic for inflation rate
? -----------------------------------------------------------------------

--> Regress; Lhs= INflat;
             Rhs = IV;  Str=Ind; Period=period; Fixed;
             Panel;  Res=Er       ? or Keep=YH
             $

+-----------------------------------------------------------------------+
| OLS Without Group Dummy Variables                                     |
| Ordinary    least squares regression    Weighting variable = none     |
| Dep. var. = INFLAT   Mean=   6.852998957    , S.D.=   5.399438779     |
| Model size: Observations =     575, Parameters =  12, Deg.Fr.=    563 |
| Residuals:  Sum of squares= 3818.827912    , Std.Dev.=        2.60442 |
| Fit:        R-squared=  .771797, Adjusted R-squared =          .76734 |
| Model test: F[ 11,    563] =  173.10,    Prob value =          .00000 |
| Diagnostic: Log-L =  -1360.2217, Restricted(b=0) Log-L =   -1785.0089 |
|             LogAmemiyaPrCrt.=    1.935, Akaike Info. Crt.=      4.773 |
| Panel Data Analysis of INFLAT      [ONE way]                          |
|            Unconditional ANOVA (No regressors)                        |
| Source      Variation        Deg. Free.     Mean Square               |
| Between       3637.56              15.         242.504                |
| Residual      13096.8             559.         23.4290                |
| Total         16734.4             574.         29.1539                |
+-----------------------------------------------------------------------+

+---------+-------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+-------------+----------------+--------+---------+----------+
 LGDPEA      -.9111364010        .41582977   -2.191   .0284     9.6582452
 PTRADE    .2299861130E-01  .11383965E-01    2.020   .0434     63.954887
 LIFE        -10.03031237        12.581166    -.797   .4253     4.2999760
 RFERT        .2836987170        .92349265     .307   .7587     2.0211209
 LINFLAT      .8110187008   .24255748E-01   33.436   .0000     6.8524598
 LRGDINV      .1730198035   .30992302E-01    5.583   .0000     23.417217
 LGGC      .5260546836E-01  .30721502E-01    1.712   .0868     16.155026
 LTRADE   -.1967132254E-01  .11353976E-01   -1.733   .0832     64.061843
 LLIFE        9.245091421        12.715153     .727   .4672     4.2997550
 LRFERT      -.1413166344        .91568440    -.154   .8774     2.0232078
 LURBAN    .8664624104E-02  .10024059E-01     .864   .3874     70.863826
 Constant     7.460316699        19.593956     .381   .7034
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
```

```
+-----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables                              |
| Ordinary    least squares regression    Weighting variable = none     |
| Dep. var. = INFLAT   Mean=   6.852998957    , S.D.=   5.399438779     |
| Model size: Observations =     575, Parameters =  27, Deg.Fr.=    548 |
| Residuals:  Sum of squares= 3376.263435    , Std.Dev.=        2.48215 |
| Fit:        R-squared=  .798244, Adjusted R-squared =          .78867 |
| Model test: F[ 26,    548] =   83.39,    Prob value =          .00000 |
| Diagnostic: Log-L =  -1324.8092, Restricted(b=0) Log-L =   -1785.0089 |
|             LogAmemiyaPrCrt.=    1.864, Akaike Info. Crt.=      4.702 |
| Estd. Autocorrelation of e(i,t)     .048457                           |
+-----------------------------------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LGDPEA	5.070180408	1.2926825	3.922	.0001	9.6582452
PTRADE	.6631503349E-01	.18302553E-01	3.623	.0003	63.954887
LIFE	-74.43986140	15.792279	-4.714	.0000	4.2999760
RFERT	.4530672527	.91726092	.494	.6214	2.0211209
LINFLAT	.7543353024	.25037644E-01	30.128	.0000	6.8524598
LRGDINV	.2604320411	.42235673E-01	6.166	.0000	23.417217
LGGC	-.3113430923E-01	.66366055E-01	-.469	.6390	16.155026
LTRADE	-.1121934904E-01	.11239155E-01	-.998	.3182	64.061843
LLIFE	34.23654302	13.085092	2.616	.0089	4.2997550
LRFERT	.2093796702	.88958813	.235	.8139	2.0232078
LURBAN	-.6066563302E-01	.30896456E-01	-1.964	.0496	70.863826

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

Test Statistics for the Classical Model

	Model	Log-Likelihood	Sum of Squares	R-squared
(1)	Constant term only	-1785.00886	.1673436106D+05	.0000000
(2)	Group effects only	-1714.54371	.1309680075D+05	.2173707
(3)	X - variables only	-1360.22168	.3818827912D+04	.7717972
(4)	X and group effects	-1324.80918	.3376263435D+04	.7982437

Hypothesis Tests

	Likelihood Ratio Test			F Tests			
	Chi-squared	d.f.	Prob.	F	num.	denom.	Prob value
(2) vs (1)	140.930	15	.00000	10.351	15	559	.00000
(3) vs (1)	849.574	11	.00000	173.100	11	563	.00000
(4) vs (1)	920.399	26	.00000	83.390	26	548	.00000
(4) vs (2)	779.469	11	.00000	143.431	11	548	.00000
(4) vs (3)	70.825	15	.00000	4.789	15	548	.00000

```
+----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables and Period Effects          |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = INFLAT  Mean=   6.852998957    , S.D.=   5.399438779     |
| Model size: Observations =     575, Parameters =  62, Deg.Fr.=   513 |
| Residuals:  Sum of squares= 2228.003322    , Std.Dev.=       2.08401 |
| Fit:        R-squared=  .866861, Adjusted R-squared =          .85103 |
| Model test: F[ 61,    513] =   54.76,    Prob value =          .00000 |
| Diagnostic: Log-L =  -1205.3058, Restricted(b=0) Log-L =   -1785.0089 |
|             LogAmemiyaPrCrt.=    1.571, Akaike Info. Crt.=      4.408 |
| Estd. Autocorrelation of e(i,t)     -.001190                         |
+----------------------------------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LGDPEA	1.310780860	1.4053377	.933	.3510	9.6582452
PTRADE	.4835885765E-02	.17683864E-01	.273	.7845	63.954887
LIFE	-19.88917789	19.325287	-1.029	.3034	4.2999760
RFERT	-.7349449401	.83002929	-.885	.3759	2.0211209
LINFLAT	.6760018848	.30211916E-01	22.375	.0000	6.8524598
LRGDINV	.1888736296	.39128210E-01	4.827	.0000	23.417217
LGGC	-.4014483802E-01	.63340719E-01	-.634	.5262	16.155026
LTRADE	.8247601519E-02	.11566818E-01	.713	.4758	64.061843
LLIFE	16.93262603	18.265653	.927	.3539	4.2997550
LRFERT	1.791946288	.81542855	2.198	.0280	2.0232078
LURBAN	-.6564084152E-01	.27273230E-01	-2.407	.0161	70.863826
Constant	.1772293782	45.768981	.004	.9969	

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

Test Statistics for the Classical Model

	Model	Log-Likelihood	Sum of Squares	R-squared
(1)	Constant term only	-1785.00886	.1673436106D+05	.0000000
(2)	Group effects only	-1714.54371	.1309680075D+05	.2173707
(3)	X - variables only	-1360.22168	.3818827912D+04	.7717972
(4)	X and group effects	-1324.80918	.3376263435D+04	.7982437
(5)	X ind.&time effects	-1205.30583	.2228003322D+04	.8668606

Hypothesis Tests

	Likelihood Ratio Test			F Tests			
	Chi-squared	d.f.	Prob.	F	num.	denom.	Prob value
(2) vs (1)	140.930	15	.00000	10.351	15	559	.00000
(3) vs (1)	849.574	11	.00000	173.100	11	563	.00000
(4) vs (1)	920.399	26	.00000	83.390	26	548	.00000
(4) vs (2)	779.469	11	.00000	143.431	11	548	.00000
(4) vs (3)	70.825	15	.00000	4.789	15	548	.00000
(5) vs (4)	239.007	35	.00000	7.554	35	513	.00000
(5) vs (3)	309.832	51	.00000	7.182	51	513	.00000

```
--> Regress ;Lhs=Y;
             Rhs= X21,  Er;
             Str=Ind;
             Period=period;
             Fixed;
             RST Er=0;
             Panel $
```

```
+----------------------------------------------------------------------+
| OLS Without Group Dummy Variables                                    |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = RGDP     Mean=   2.920488278    , S.D.=   2.730104755    |
| Model size: Observations =     575, Parameters =  10, Deg.Fr.=   565 |
| Residuals:  Sum of squares= 2552.745848    , Std.Dev.=      2.12559 |
| Fit:        R-squared=  .403326, Adjusted R-squared =        .39382 |
| Model test: F[  9,    565] =   42.44,    Prob value =        .00000 |
| Diagnostic: Log-L =  -1244.4242, Restricted(b=0) Log-L =  -1392.8847 |
|             LogAmemiyaPrCrt.=    1.525, Akaike Info. Crt.=     4.363 |
| Panel Data Analysis of RGDP       [ONE way]                          |
|           Unconditional ANOVA (No regressors)                        |
| Source      Variation        Deg. Free.     Mean Square              |
| Between       301.508             15.         20.1005                |
| Residual      3976.79            559.         7.11411                |
| Total         4278.29            574.         7.45347                |
+----------------------------------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LGDPEA	-2.318343215	.33948515	-6.829	.0000	9.6582452
INFLAT	-.2366816070	.21264255E-01	-11.130	.0000	6.8529990
RGDINV	.2424587462	.25231159E-01	9.609	.0000	23.430261
GGC	-.1210976158E-01	.25237947E-01	-.480	.6314	16.150574
PTRADE	.7196686837E-02	.24868733E-02	2.894	.0038	63.954887
LIFE	-5.181652554	3.7476707	-1.383	.1668	4.2999760
RFERT	-.5146586051	.23035160	-2.234	.0255	2.0211209
PURBAN	.1211416447E-01	.81789415E-02	1.481	.1386	70.838609
ER	-.4565136135E-01	.36812249E-01	-1.240	.2149	.39698912E-01
Constant	43.45286973	15.661777	2.774	.0055	

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

```
+----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables                             |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = RGDP     Mean=   2.920488278    , S.D.=   2.730104755    |
| Model size: Observations =     575, Parameters =  25, Deg.Fr.=   550 |
| Residuals:  Sum of squares= 2154.231997    , Std.Dev.=       1.97909 |
| Fit:        R-squared=  .496474, Adjusted R-squared =         .47450 |
| Model test: F[ 24,    550] =   22.60,    Prob value =         .00000 |
| Diagnostic: Log-L =  -1195.6253, Restricted(b=0) Log-L =  -1392.8847 |
|             LogAmemiyaPrCrt.=    1.408, Akaike Info. Crt.=     4.246 |
| Estd. Autocorrelation of e(i,t)     .187586                          |
+----------------------------------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LGDPEA	-3.625579812	1.0299126	-3.520	.0004	9.6582452
INFLAT	-.2516353484	.22976173E-01	-10.952	.0000	6.8529990
RGDINV	.2769935574	.34443610E-01	8.042	.0000	23.430261
GGC	-.1953143681	.59341777E-01	-3.291	.0010	16.150574
PTRADE	.8407554933E-01	.12268148E-01	6.853	.0000	63.954887
LIFE	-12.42452173	8.8697435	-1.401	.1613	4.2999760
RFERT	-1.090618622	.32816504	-3.323	.0009	2.0211209
PURBAN	.4038431972E-01	.29801525E-01	1.355	.1754	70.838609
ER	-.5760883289E-01	.35521292E-01	-1.622	.1048	.39698912E-01

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

Test Statistics for the Classical Model

	Model	Log-Likelihood	Sum of Squares	R-squared
(1)	Constant term only	-1392.88471	.4278292912D+04	.0000000
(2)	Group effects only	-1371.87411	.3976785128D+04	.0704739
(3)	X - variables only	-1244.42417	.2552745848D+04	.4033261
(4)	X and group effects	-1195.62527	.2154231997D+04	.4964739

Hypothesis Tests

	Likelihood Ratio Test			F Tests			
	Chi-squared	d.f.	Prob.	F	num.	denom.	Prob value
(2) vs (1)	42.021	15	.00022	2.825	15	559	.00029
(3) vs (1)	296.921	9	.00000	42.435	9	565	.00000
(4) vs (1)	394.519	24	.00000	22.596	24	550	.00000
(4) vs (2)	352.498	9	.00000	51.702	9	550	.00000
(4) vs (3)	97.598	15	.00000	6.783	15	550	.00000

```
+----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables and Period Effects           |
| Ordinary    least squares regression    Weighting variable = none      |
| Dep. var. = RGDP     Mean=   2.920488278    , S.D.=   2.730104755      |
| Model size: Observations =     575, Parameters =  60, Deg.Fr.=    515  |
| Residuals:  Sum of squares= 1557.640251    , Std.Dev.=        1.73912 |
| Fit:        R-squared=  .635920, Adjusted R-squared =          .59421 |
| Model test: F[ 59,     515] =   15.25,     Prob value =          .00000 |
| Diagnostic: Log-L =  -1102.3999, Restricted(b=0) Log-L =   -1392.8847 |
|             LogAmemiyaPrCrt.=    1.206, Akaike Info. Crt.=      4.043 |
| Estd. Autocorrelation of e(i,t)     .147652                            |
+----------------------------------------------------------------------+
+---------+-------------+---------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+-------------+---------------+--------+---------+----------+
 LGDPEA      -6.057190079       1.1618978    -5.213   .0000     9.6582452
 INFLAT      -.2452776306   .33809598E-01    -7.255   .0000     6.8529990
 RGDINV       .2661549227   .33066247E-01     8.049   .0000     23.430261
 GGC         -.2042171640   .59149803E-01    -3.453   .0006     16.150574
 PTRADE    .8250519417E-01  .12260814E-01     6.729   .0000     63.954887
 LIFE        -20.99171875       9.7552284    -2.152   .0314     4.2999760
 RFERT       -.5446913189       .30993127    -1.757   .0788     2.0211209
 PURBAN    .4466312316E-01  .27341905E-01     1.634   .1024     70.838609
 ER           .1067807333   .49777310E-01     2.145   .0319  .39698912E-01
 Constant     143.0853993       37.539017     3.812   .0001
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
```

```
+----------------------------------------------------------------------+
|               Test Statistics for the Classical Model                 |
|                                                                       |
|        Model              Log-Likelihood    Sum of Squares    R-squared |
| (1)  Constant term only      -1392.88471   .4278292912D+04     .0000000 |
| (2)  Group effects only      -1371.87411   .3976785128D+04     .0704739 |
| (3)  X - variables only      -1244.42417   .2552745848D+04     .4033261 |
| (4)  X and group effects     -1195.62527   .2154231997D+04     .4964739 |
| (5)  X ind.&time effects     -1102.39987   .1557640251D+04     .6359201 |
|                                                                       |
|                           Hypothesis Tests                            |
|             Likelihood Ratio Test                  F Tests            |
|         Chi-squared   d.f.   Prob.            F    num. denom. Prob value |
| (2) vs (1)    42.021     15     .00022      2.825   15    559     .00029 |
| (3) vs (1)   296.921      9     .00000     42.435    9    565     .00000 |
| (4) vs (1)   394.519     24     .00000     22.596   24    550     .00000 |
| (4) vs (2)   352.498      9     .00000     51.702    9    550     .00000 |
| (4) vs (3)    97.598     15     .00000      6.783   15    550     .00000 |
| (5) vs (4)   186.451     35     .00000      5.636   35    515     .00000 |
| (5) vs (3)   284.049     51     .00000      6.451   51    515     .00000 |
+----------------------------------------------------------------------+
```

```
--> Calc; list; LL0=LogL$
    LL0      = -.11023998682704650D+04
```

```
--> Regress ;Lhs=Y;
            Rhs=X21;
            Str=Ind;
            Period=period;
            Fixed;
            Panel $
```

```
+----------------------------------------------------------------------+
| OLS Without Group Dummy Variables                                    |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = RGDP     Mean=   2.923428403    , S.D.=   2.728642254    |
| Model size: Observations =     576, Parameters =   9, Deg.Fr.=    567 |
| Residuals:  Sum of squares= 2559.785135    , Std.Dev.=        2.12476 |
| Fit:        R-squared=  .402081, Adjusted R-squared =          .39364 |
| Model test: F[  8,    567] =   47.66,    Prob value =          .00000 |
| Diagnostic: Log-L =  -1246.8810, Restricted(b=0) Log-L =   -1394.9994 |
|             LogAmemiyaPrCrt.=    1.523, Akaike Info. Crt.=      4.361 |
| Panel Data Analysis of RGDP       [ONE way]                          |
|           Unconditional ANOVA (No regressors)                        |
| Source      Variation        Deg. Free.     Mean Square              |
| Between       300.599              15.         20.0399               |
| Residual      3980.56             560.         7.10814               |
| Total         4281.16             575.         7.44549               |
+----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDPEA      -2.378869522       .33506420    -7.100   .0000     9.6576111
 INFLAT      -.2480965368   .19120869E-01   -12.975   .0000     6.8435319
 RGDINV       .2458873787   .25071319E-01     9.808   .0000     23.426389
 GGC      -.9339845527E-02   .25127287E-01    -.372   .7101     16.143889
 PTRADE    .7208001029E-02   .24858817E-02    2.900   .0037     63.987083
 LIFE        -4.944183290      3.7398291     -1.322   .1862     4.2999070
 RFERT       -.5403873250       .22930937    -2.357   .0184     2.0221085
 PURBAN    .1181958944E-01   .81328371E-02    1.453   .1461     70.876910
 Constant     43.03930508       15.638346     2.752   .0059
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
```

```
+----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables                             |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = RGDP     Mean=   2.923428403    , S.D.=   2.728642254    |
| Model size: Observations =     576, Parameters =  24, Deg.Fr.=    552 |
| Residuals:  Sum of squares= 2166.360550    , Std.Dev.=        1.98105 |
| Fit:        R-squared=  .493978, Adjusted R-squared =          .47289 |
| Model test: F[ 23,     552] =    23.43,    Prob value =         .00000 |
| Diagnostic: Log-L =  -1198.8211, Restricted(b=0) Log-L =    -1394.9994 |
|             LogAmemiyaPrCrt.=    1.408, Akaike Info. Crt.=      4.246 |
| Estd. Autocorrelation of e(i,t)     .185521                          |
+----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDPEA      -3.451555806       1.0159552    -3.397   .0007      9.6576111
 INFLAT      -.2688656720   .20285087E-01   -13.254   .0000      6.8435319
 RGDINV       .2846775653   .34102117E-01     8.348   .0000      23.426389
 GGC         -.1898408097   .59262418E-01    -3.203   .0014      16.143889
 PTRADE    .8108955241E-01  .12134754E-01     6.682   .0000      63.987083
 LIFE        -13.87075805       8.7769884    -1.580   .1140      4.2999070
 RFERT       -1.138165551        .32736350   -3.477   .0005      2.0221085
 PURBAN    .4135041098E-01  .29753296E-01     1.390   .1646      70.876910
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

+-----------------------------------------------------------------------+
|               Test Statistics for the Classical Model                 |
|                                                                       |
|       Model              Log-Likelihood    Sum of Squares    R-squared |
| (1)  Constant term only     -1394.99935   .4281155915D+04    .0000000 |
| (2)  Group effects only     -1374.03257   .3980556887D+04    .0702145 |
| (3)  X - variables only     -1246.88103   .2559785135D+04    .4020808 |
| (4)  X and group effects    -1198.82111   .2166360550D+04    .4939777 |
|                                                                       |
|                           Hypothesis Tests                            |
|                Likelihood Ratio Test                F Tests           |
|           Chi-squared   d.f.  Prob.          F    num. denom. Prob value |
| (2) vs (1)    41.934     15      .00023      2.819   15    560    .00029 |
| (3) vs (1)   296.237      8      .00000     47.661    8    567    .00000 |
| (4) vs (1)   392.356     23      .00000     23.429   23    552    .00000 |
| (4) vs (2)   350.423      8      .00000     57.783    8    552    .00000 |
| (4) vs (3)    96.120     15      .00000      6.683   15    552    .00000 |
+-----------------------------------------------------------------------+
```

```
+----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables and Period Effects          |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = RGDP     Mean=   2.923428403    , S.D.=   2.728642254    |
| Model size: Observations =     576, Parameters =  59, Deg.Fr.=   517 |
| Residuals:  Sum of squares= 1579.264130    , Std.Dev.=       1.74776 |
| Fit:        R-squared=  .631113, Adjusted R-squared =         .58973 |
| Model test: F[ 58,    517] =   15.25,    Prob value =         .00000 |
| Diagnostic: Log-L =  -1107.7873, Restricted(b=0) Log-L =  -1394.9994 |
|             LogAmemiyaPrCrt.=    1.214, Akaike Info. Crt.=     4.051 |
| Estd. Autocorrelation of e(i,t)     .155076                          |
+----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDPEA      -6.180264289       1.1665175   -5.298   .0000     9.6576111
 INFLAT      -.1963587966   .25222341E-01   -7.785   .0000     6.8435319
 RGDINV       .2571240958   .32990621E-01    7.794   .0000     23.426389
 GGC         -.2038151656   .59428704E-01   -3.430   .0006     16.143889
 PTRADE    .7911324685E-01  .12210281E-01    6.479   .0000     63.987083
 LIFE        -22.27672987       9.7601218   -2.282   .0225     4.2999070
 RFERT       -.6449607403       .30891343   -2.088   .0368     2.0221085
 PURBAN    .5211116459E-01  .27329914E-01    1.907   .0566     70.876910
 Constant     149.5570293       37.519112    3.986   .0001
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

+-----------------------------------------------------------------------+
|                Test Statistics for the Classical Model                |
|                                                                       |
|        Model             Log-Likelihood    Sum of Squares    R-squared |
| (1)  Constant term only    -1394.99935   .4281155915D+04     .0000000 |
| (2)  Group effects only    -1374.03257   .3980556887D+04     .0702145 |
| (3)  X - variables only    -1246.88103   .2559785135D+04     .4020808 |
| (4)  X and group effects   -1198.82111   .2166360550D+04     .4939777 |
| (5)  X ind.&time effects   -1107.78730   .1579264130D+04     .6311127 |
|                                                                       |
|                                Hypothesis Tests                       |
|                 Likelihood Ratio Test                F Tests          |
|            Chi-squared   d.f.  Prob.          F    num. denom. Prob value |
| (2) vs (1)     41.934     15     .00023     2.819   15    560     .00029 |
| (3) vs (1)    296.237      8     .00000    47.661    8    567     .00000 |
| (4) vs (1)    392.356     23     .00000    23.429   23    552     .00000 |
| (4) vs (2)    350.423      8     .00000    57.783    8    552     .00000 |
| (4) vs (3)     96.120     15     .00000     6.683   15    552     .00000 |
| (5) vs (4)    182.068     35     .00000     5.491   35    517     .00000 |
| (5) vs (3)    278.187     51     .00000     6.294   51    517     .00000 |
+-----------------------------------------------------------------------+
--> Calc; list; LL1=LogL$
    LL1     = -.11077873016150570D+04

? Durbin-Wu-Hausman test (LR) for endogeneity

--> Calc; list; LR=2*(LL0-LL1)$
    LR      =  .10774866689182550D+02
--> Calc; list; Prob=1-Chi(LR, 1)$
    PROB    =  .10288762910081180D-02
--> Calc; list; ctb(0.95, 1)$
    Result  =  .38414591508300020D+01
```

```
? ------------------------------------------------------------------
? Durbin-Wu-Hausman test statistic for investment ratio
? ------------------------------------------------------------------

--> Regress; Lhs= RGDINV ;
             Rhs = IV;  Str=Ind; Period=period; Fixed;
             Panel;  Res=Er       ? or Keep=YH
             $

+--------------------------------------------------------------------+
| OLS Without Group Dummy Variables                                  |
| Ordinary    least squares regression    Weighting variable = none  |
| Dep. var. = RGDINV   Mean=   23.43026087    , S.D.=   4.881575519  |
| Model size: Observations =      575, Parameters =  12, Deg.Fr.=   563 |
| Residuals:  Sum of squares= 2306.428964    , Std.Dev.=       2.02402 |
| Fit:        R-squared=  .831380, Adjusted R-squared =        .82809 |
| Model test: F[ 11,    563] =  252.35,    Prob value =        .00000 |
| Diagnostic: Log-L =  -1215.2518, Restricted(b=0) Log-L =  -1727.0333 |
|             LogAmemiyaPrCrt.=    1.431, Akaike Info. Crt.=     4.269 |
| Panel Data Analysis of RGDINV      [ONE way]                       |
|           Unconditional ANOVA (No regressors)                      |
| Source      Variation        Deg. Free.     Mean Square           |
| Between       6431.56             15.          428.771            |
| Residual      7246.73            559.          12.9637            |
| Total         13678.3            574.          23.8298            |
+--------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDPEA   -.5884579682E-01      .32316221     -.182   .8555     9.6582452
 PTRADE   -.4282229788E-02  .88470518E-02     -.484   .6284     63.954887
 LIFE        -55.94422416       9.7774562    -5.722   .0000     4.2999760
 RFERT       -1.398096327       .71769256    -1.948   .0514     2.0211209
 LINFLAT  -.8464290204E-01  .18850361E-01    -4.490   .0000     6.8524598
 LRGDINV      .8589405506   .24085676E-01    35.662   .0000     23.417217
 LGGC     -.8942756245E-01  .23875223E-01    -3.746   .0002     16.155026
 LTRADE   -.4441174395E-03  .88237455E-02     -.050   .9599     64.061843
 LLIFE        51.99032397       9.8815841     5.261   .0000     4.2997550
 LRFERT       1.215792396       .71162437     1.708   .0875     2.0232078
 LURBAN   -.1293745686E-01  .77902004E-02    -1.661   .0968     70.863826
 Constant     24.50753196       15.227448     1.609   .1075
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
```

```
+----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables                             |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = RGDINV   Mean=   23.43026087    , S.D.=   4.881575519    |
| Model size: Observations =     575, Parameters =  27, Deg.Fr.=    548 |
| Residuals:  Sum of squares= 2090.521004    , Std.Dev.=        1.95316 |
| Fit:        R-squared=  .847165, Adjusted R-squared =          .83991 |
| Model test: F[ 26,    548] =  116.83,    Prob value =          .00000 |
| Diagnostic: Log-L =  -1186.9943, Restricted(b=0) Log-L =   -1727.0333 |
|             LogAmemiyaPrCrt.=    1.385, Akaike Info. Crt.=      4.223 |
| Estd. Autocorrelation of e(i,t)     .109596                          |
+----------------------------------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LGDPEA	-.7135715628	1.0171874	-.702	.4830	9.6582452
PTRADE	.4077827070E-01	.14401933E-01	2.831	.0046	63.954887
LIFE	-56.06831937	12.426646	-4.512	.0000	4.2999760
RFERT	-.9339705028	.72177527	-1.294	.1957	2.0211209
LINFLAT	-.5097478995E-01	.19701648E-01	-2.587	.0097	6.8524598
LRGDINV	.7234775610	.33234452E-01	21.769	.0000	23.417217
LGGC	-.2433119535	.52222193E-01	-4.659	.0000	16.155026
LTRADE	-.6011768660E-02	.88438787E-02	-.680	.4967	64.061843
LLIFE	48.04326173	10.296412	4.666	.0000	4.2997550
LRFERT	1.154928604	.70000007	1.650	.0990	2.0232078
LURBAN	.7749068047E-02	.24311837E-01	.319	.7499	70.863826

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

```
+----------------------------------------------------------------------+
|                  Test Statistics for the Classical Model             |
|                                                                      |
|          Model            Log-Likelihood    Sum of Squares    R-squared |
| (1)   Constant term only     -1727.03333   .1367829346D+05     .0000000 |
| (2)   Group effects only     -1544.39629   .7246733802D+04     .4702019 |
| (3)   X - variables only     -1215.25179   .2306428964D+04     .8313804 |
| (4)   X and group effects    -1186.99424   .2090521004D+04     .8471651 |
|                                                                      |
|                               Hypothesis Tests                       |
|                 Likelihood Ratio Test                F Tests          |
|            Chi-squared   d.f.  Prob.         F     num. denom. Prob value |
| (2) vs (1)    365.274     15      .00000    33.075   15   559      .00000 |
| (3) vs (1)   1023.563     11      .00000   252.352   11   563      .00000 |
| (4) vs (1)   1080.078     26      .00000   116.830   26   548      .00000 |
| (4) vs (2)    714.804     11      .00000   122.875   11   548      .00000 |
| (4) vs (3)     56.515     15      .00000     3.773   15   548      .00000 |
+----------------------------------------------------------------------+
```

Least Squares with Group Dummy Variables and Period Effects
Ordinary least squares regression Weighting variable = none
Dep. var. = RGDINV Mean= 23.43026087 , S.D.= 4.881575519
Model size: Observations = 575, Parameters = 62, Deg.Fr.= 513
Residuals: Sum of squares= 1494.961031 , Std.Dev.= 1.70709
Fit: R-squared= .890706, Adjusted R-squared = .87771
Model test: F[61, 513] = 68.54, Prob value = .00000
Diagnostic: Log-L = -1090.5917, Restricted(b=0) Log-L = -1727.0333
LogAmemiyaPrCrt.= 1.172, Akaike Info. Crt.= 4.009
Estd. Autocorrelation of e(i,t) .124121

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LGDPEA	-1.147551974	1.1511653	-.997	.3188	9.6582452
PTRADE	.4660796823E-01	.14485523E-01	3.218	.0013	63.954887
LIFE	27.62452592	15.830075	1.745	.0810	4.2999760
RFERT	-2.428323214	.67990845	-3.572	.0004	2.0211209
LINFLAT	-.7746489426E-01	.24747725E-01	-3.130	.0017	6.8524598
LRGDINV	.7239477204	.32051400E-01	22.587	.0000	23.417217
LGGC	-.2248644786	.51884783E-01	-4.334	.0000	16.155026
LTRADE	-.1948901341E-01	.94748192E-02	-2.057	.0397	64.061843
LLIFE	-14.60467736	14.962089	-.976	.3290	4.2997550
LRFERT	2.988971638	.66794843	4.475	.0000	2.0232078
LURBAN	.1658355446E-01	.22340536E-01	.742	.4579	70.863826
Constant	-38.31084511	37.491107	-1.022	.3068	

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

Test Statistics for the Classical Model

	Model	Log-Likelihood	Sum of Squares	R-squared
(1)	Constant term only	-1727.03333	.1367829346D+05	.0000000
(2)	Group effects only	-1544.39629	.7246733802D+04	.4702019
(3)	X - variables only	-1215.25179	.2306428964D+04	.8313804
(4)	X and group effects	-1186.99424	.2090521004D+04	.8471651
(5)	X ind.&time effects	-1090.59170	.1494961031D+04	.8907056

Hypothesis Tests

	Likelihood Ratio Test			F Tests			
	Chi-squared	d.f.	Prob.	F	num.	denom.	Prob value
(2) vs (1)	365.274	15	.00000	33.075	15	559	.00000
(3) vs (1)	1023.563	11	.00000	252.352	11	563	.00000
(4) vs (1)	1080.078	26	.00000	116.830	26	548	.00000
(4) vs (2)	714.804	11	.00000	122.875	11	548	.00000
(4) vs (3)	56.515	15	.00000	3.773	15	548	.00000
(5) vs (4)	192.805	35	.00000	5.839	35	513	.00000
(5) vs (3)	249.320	51	.00000	5.460	51	513	.00000

```
--> Regress ;Lhs=Y;
            Rhs= X21,  Er;
            Str=Ind;
            Period=period;
            Fixed;
            RST Er=0;
            Panel $
```

```
+--------------------------------------------------------------------------+
| OLS Without Group Dummy Variables                                        |
| Ordinary    least squares regression    Weighting variable = none        |
| Dep. var. = RGDP     Mean=   2.920488278    , S.D.=    2.730104755       |
| Model size: Observations =     575, Parameters =  10, Deg.Fr.=    565    |
| Residuals:  Sum of squares= 2518.817935    , Std.Dev.=        2.11142    |
| Fit:        R-squared=  .411256, Adjusted R-squared =          .40188    |
| Model test: F[  9,    565] =   43.85,    Prob value =          .00000    |
| Diagnostic: Log-L =  -1240.5775, Restricted(b=0) Log-L =   -1392.8847    |
|             LogAmemiyaPrCrt.=    1.512, Akaike Info. Crt.=      4.350    |
| Panel Data Analysis of RGDP        [ONE way]                             |
|           Unconditional ANOVA (No regressors)                            |
| Source      Variation        Deg. Free.     Mean Square                  |
| Between       301.508             15.          20.1005                   |
| Residual      3976.79            559.          7.11411                   |
| Total         4278.29            574.          7.45347                   |
+--------------------------------------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LGDPEA	-2.236996011	.33681282	-6.642	.0000	9.6582452
INFLAT	-.2411740596	.19149604E-01	-12.594	.0000	6.8529990
RGDINV	.2191815531	.26426157E-01	8.294	.0000	23.430261
GGC	-.2085739112E-01	.25261121E-01	-.826	.4090	16.150574
PTRADE	.6428792565E-02	.24836610E-02	2.588	.0096	63.954887
LIFE	-5.030868232	3.7186079	-1.353	.1761	4.2999760
RFERT	-.5484575984	.22788761	-2.407	.0161	2.0211209
PURBAN	.8781448912E-02	.81897168E-02	1.072	.2836	70.838609
ER	.1097466643	.36243479E-01	3.028	.0025	.26061102
Constant	43.05938011	15.555319	2.768	.0056	

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

```
+-----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables                              |
| Ordinary    least squares regression    Weighting variable = none     |
| Dep. var. = RGDP     Mean=    2.920488278    , S.D.=    2.730104755   |
| Model size: Observations =      575, Parameters =  25, Deg.Fr.=    550 |
| Residuals:  Sum of squares= 2148.311712     , Std.Dev.=        1.97637 |
| Fit:        R-squared=  .497858, Adjusted R-squared =          .47595 |
| Model test: F[ 24,     550] =   22.72,    Prob value =          .00000 |
| Diagnostic: Log-L =  -1194.8341, Restricted(b=0) Log-L =   -1392.8847 |
|             LogAmemiyaPrCrt.=    1.405, Akaike Info. Crt.=      4.243 |
| Estd. Autocorrelation of e(i,t)      .183543                          |
+-----------------------------------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LGDPEA	-2.964350961	1.0388528	-2.853	.0043	9.6582452
INFLAT	-.2621513396	.20534003E-01	-12.767	.0000	6.8529990
RGDINV	.2507600779	.37981115E-01	6.602	.0000	23.430261
GGC	-.2083693073	.59890074E-01	-3.479	.0005	16.150574
PTRADE	.7962367481E-01	.12246025E-01	6.502	.0000	63.954887
LIFE	-17.76228730	8.9417835	-1.986	.0470	4.2999760
RFERT	-1.104005934	.32708413	-3.375	.0007	2.0211209
PURBAN	.4587686431E-01	.29903388E-01	1.534	.1250	70.838609
ER	.7378692947E-01	.36206614E-01	2.038	.0416	.26061102

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

Test Statistics for the Classical Model

	Model	Log-Likelihood	Sum of Squares	R-squared
(1)	Constant term only	-1392.88471	.4278292912D+04	.0000000
(2)	Group effects only	-1371.87411	.3976785128D+04	.0704739
(3)	X - variables only	-1240.57746	.2518817935D+04	.4112563
(4)	X and group effects	-1194.83407	.2148311712D+04	.4978577

Hypothesis Tests

	Likelihood Ratio Test			F Tests			
	Chi-squared	d.f.	Prob.	F	num.	denom.	Prob value
(2) vs (1)	42.021	15	.00022	2.825	15	559	.00029
(3) vs (1)	304.615	9	.00000	43.852	9	565	.00000
(4) vs (1)	396.101	24	.00000	22.721	24	550	.00000
(4) vs (2)	354.080	9	.00000	52.013	9	550	.00000
(4) vs (3)	91.487	15	.00000	6.324	15	550	.00000

```
+----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables and Period Effects          |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = RGDP     Mean=   2.920488278    , S.D.=   2.730104755    |
| Model size: Observations =     575, Parameters =  60, Deg.Fr.=   515 |
| Residuals:  Sum of squares= 1356.542839    , Std.Dev.=       1.62298 |
| Fit:        R-squared=  .682924, Adjusted R-squared =         .64660 |
| Model test: F[ 59,    515] =   18.80,    Prob value =         .00000 |
| Diagnostic: Log-L =  -1062.6580, Restricted(b=0) Log-L =   -1392.8847 |
|             LogAmemiyaPrCrt.=    1.068, Akaike Info. Crt.=     3.905 |
| Estd. Autocorrelation of e(i,t)     .092665                          |
+----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDPEA      -4.659563551       1.0958575    -4.252   .0000     9.6582452
 INFLAT      -.1656758421   .23672462E-01    -6.999   .0000     6.8529990
 RGDINV   -.7289360104E-02  .42411342E-01     -.172   .8635     23.430261
 GGC         -.3131347007   .56540742E-01    -5.538   .0000     16.150574
 PTRADE    .9015888450E-01  .11474745E-01     7.857   .0000     63.954887
 LIFE        -20.71351027       9.0718920    -2.283   .0224     4.2999760
 RFERT       -.3000767233       .28933330    -1.037   .2997     2.0211209
 PURBAN    .6113290424E-01  .25488968E-01     2.398   .0165     70.838609
 ER           .5291277987   .58565078E-01     9.035   .0000     .26061102
 Constant     133.7266900       34.907684     3.831   .0001
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

+-------------------------------------------------------------------------+
|                Test Statistics for the Classical Model                  |
|                                                                         |
|        Model             Log-Likelihood    Sum of Squares    R-squared  |
| (1)   Constant term only    -1392.88471   .4278292912D+04      .0000000 |
| (2)   Group effects only    -1371.87411   .3976785128D+04      .0704739 |
| (3)   X - variables only    -1240.57746   .2518817935D+04      .4112563 |
| (4)   X and group effects   -1194.83407   .2148311712D+04      .4978577 |
| (5)   X ind.&time effects   -1062.65800   .1356542839D+04      .6829243 |
|                                                                         |
|                                 Hypothesis Tests                        |
|                Likelihood Ratio Test               F Tests              |
|           Chi-squared   d.f.   Prob.          F    num. denom. Prob value |
| (2) vs (1)    42.021      15     .00022      2.825   15   559     .00029 |
| (3) vs (1)   304.615       9     .00000     43.852    9   565     .00000 |
| (4) vs (1)   396.101      24     .00000     22.721   24   550     .00000 |
| (4) vs (2)   354.080       9     .00000     52.013    9   550     .00000 |
| (4) vs (3)    91.487      15     .00000      6.324   15   550     .00000 |
| (5) vs (4)   264.352      35     .00000      8.588   35   515     .00000 |
| (5) vs (3)   355.839      51     .00000      8.652   51   515     .00000 |
+-------------------------------------------------------------------------+
--> Calc; list; LL0=LogL$
    LL0      = -.10626580005691850D+04
```

```
--> Regress ;Lhs=Y;
            Rhs=X21;
            Str=Ind;
            Period=period;
            Fixed;
            Panel $
```

```
+----------------------------------------------------------------------+
| OLS Without Group Dummy Variables                                    |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = RGDP     Mean=   2.923428403    , S.D.=   2.728642254    |
| Model size: Observations =     576, Parameters =   9, Deg.Fr.=    567 |
| Residuals:  Sum of squares= 2559.785135    , Std.Dev.=        2.12476 |
| Fit:        R-squared=  .402081, Adjusted R-squared =          .39364 |
| Model test: F[  8,    567] =   47.66,    Prob value =          .00000 |
| Diagnostic: Log-L =  -1246.8810, Restricted(b=0) Log-L =   -1394.9994 |
|             LogAmemiyaPrCrt.=    1.523, Akaike Info. Crt.=      4.361 |
| Panel Data Analysis of RGDP       [ONE way]                          |
|           Unconditional ANOVA (No regressors)                        |
| Source      Variation        Deg. Free.     Mean Square             |
| Between       300.599              15.         20.0399              |
| Residual      3980.56             560.         7.10814              |
| Total         4281.16             575.         7.44549              |
+----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDPEA      -2.378869522       .33506420    -7.100   .0000    9.6576111
 INFLAT      -.2480965368   .19120869E-01   -12.975   .0000    6.8435319
 RGDINV       .2458873787   .25071319E-01     9.808   .0000    23.426389
 GGC       -.9339845527E-02 .25127287E-01     -.372   .7101    16.143889
 PTRADE    .7208001029E-02  .24858817E-02     2.900   .0037    63.987083
 LIFE        -4.944183290       3.7398291    -1.322   .1862    4.2999070
 RFERT       -.5403873250       .22930937    -2.357   .0184    2.0221085
 PURBAN    .1181958944E-01  .81328371E-02     1.453   .1461    70.876910
 Constant     43.03930508       15.638346     2.752   .0059
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
```

```
+-----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables                              |
| Ordinary    least squares regression    Weighting variable = none     |
| Dep. var. = RGDP     Mean=   2.923428403    , S.D.=   2.728642254     |
| Model size: Observations =     576, Parameters =  24, Deg.Fr.=    552 |
| Residuals:  Sum of squares= 2166.360550    , Std.Dev.=        1.98105 |
| Fit:        R-squared=  .493978, Adjusted R-squared =          .47289 |
| Model test: F[ 23,    552] =   23.43,    Prob value =          .00000 |
| Diagnostic: Log-L =  -1198.8211, Restricted(b=0) Log-L =   -1394.9994 |
|             LogAmemiyaPrCrt.=    1.408, Akaike Info. Crt.=      4.246 |
| Estd. Autocorrelation of e(i,t)     .185521                           |
+-----------------------------------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LGDPEA	-3.451555806	1.0159552	-3.397	.0007	9.6576111
INFLAT	-.2688656720	.20285087E-01	-13.254	.0000	6.8435319
RGDINV	.2846775653	.34102117E-01	8.348	.0000	23.426389
GGC	-.1898408097	.59262418E-01	-3.203	.0014	16.143889
PTRADE	.8108955241E-01	.12134754E-01	6.682	.0000	63.987083
LIFE	-13.87075805	8.7769884	-1.580	.1140	4.2999070
RFERT	-1.138165551	.32736350	-3.477	.0005	2.0221085
PURBAN	.4135041098E-01	.29753296E-01	1.390	.1646	70.876910

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

Test Statistics for the Classical Model

	Model	Log-Likelihood	Sum of Squares	R-squared
(1)	Constant term only	-1394.99935	.4281155915D+04	.0000000
(2)	Group effects only	-1374.03257	.3980556887D+04	.0702145
(3)	X - variables only	-1246.88103	.2559785135D+04	.4020808
(4)	X and group effects	-1198.82111	.2166360550D+04	.4939777

Hypothesis Tests

	Likelihood Ratio Test			F Tests			
	Chi-squared	d.f.	Prob.	F	num.	denom.	Prob value
(2) vs (1)	41.934	15	.00023	2.819	15	560	.00029
(3) vs (1)	296.237	8	.00000	47.661	8	567	.00000
(4) vs (1)	392.356	23	.00000	23.429	23	552	.00000
(4) vs (2)	350.423	8	.00000	57.783	8	552	.00000
(4) vs (3)	96.120	15	.00000	6.683	15	552	.00000

```
+----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables and Period Effects          |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = RGDP     Mean=   2.923428403    , S.D.=   2.728642254    |
| Model size: Observations =     576, Parameters =  59, Deg.Fr.=    517 |
| Residuals:  Sum of squares= 1579.264130    , Std.Dev.=        1.74776 |
| Fit:        R-squared=  .631113, Adjusted R-squared =          .58973 |
| Model test: F[ 58,     517] =   15.25,    Prob value =         .00000 |
| Diagnostic: Log-L =  -1107.7873, Restricted(b=0) Log-L =   -1394.9994 |
|             LogAmemiyaPrCrt.=    1.214, Akaike Info. Crt.=      4.051 |
| Estd. Autocorrelation of e(i,t)     .155076                          |
+----------------------------------------------------------------------+
+---------+-------------+---------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+-------------+---------------+--------+---------+----------+
 LGDPEA      -6.180264289       1.1665175   -5.298   .0000     9.6576111
 INFLAT      -.1963587966   .25222341E-01   -7.785   .0000     6.8435319
 RGDINV       .2571240958   .32990621E-01    7.794   .0000     23.426389
 GGC         -.2038151656   .59428704E-01   -3.430   .0006     16.143889
 PTRADE    .7911324685E-01  .12210281E-01    6.479   .0000     63.987083
 LIFE        -22.27672987       9.7601218   -2.282   .0225     4.2999070
 RFERT       -.6449607403       .30891343   -2.088   .0368     2.0221085
 PURBAN    .5211116459E-01  .27329914E-01    1.907   .0566     70.876910
 Constant     149.5570293       37.519112    3.986   .0001
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

+------------------------------------------------------------------------+
|                Test Statistics for the Classical Model                 |
|                                                                        |
|        Model              Log-Likelihood    Sum of Squares    R-squared |
| (1)  Constant term only    -1394.99935    .4281155915D+04     .0000000 |
| (2)  Group effects only    -1374.03257    .3980556887D+04     .0702145 |
| (3)  X - variables only    -1246.88103    .2559785135D+04     .4020808 |
| (4)  X and group effects   -1198.82111    .2166360550D+04     .4939777 |
| (5)  X ind.&time effects   -1107.78730    .1579264130D+04     .6311127 |
|                                                                        |
|                             Hypothesis Tests                           |
|                Likelihood Ratio Test                F Tests            |
|           Chi-squared   d.f.  Prob.          F    num. denom. Prob value |
| (2) vs (1)    41.934     15     .00023     2.819   15    560     .00029 |
| (3) vs (1)   296.237      8     .00000    47.661    8    567     .00000 |
| (4) vs (1)   392.356     23     .00000    23.429   23    552     .00000 |
| (4) vs (2)   350.423      8     .00000    57.783    8    552     .00000 |
| (4) vs (3)    96.120     15     .00000     6.683   15    552     .00000 |
| (5) vs (4)   182.068     35     .00000     5.491   35    517     .00000 |
| (5) vs (3)   278.187     51     .00000     6.294   51    517     .00000 |
+------------------------------------------------------------------------+
--> Calc; list; LL1=LogL$
    LL1      = -.11077873016150570D+04


? Durbin-Wu-Hausman test (LR) for endogeneity

--> Calc; list; LR=2*(LL0-LL1)$
    LR       =  .90258602091743800D+02

--> Calc; list; Prob=1-Chi(LR, 1)$
    PROB     =  .00000000000000000D+00

--> Calc; list; ctb(0.95, 1)$
    Result   =  .38414591508300020D+01
```

```
? ------------------------------------------------------------------
? Durbin-Wu-Hausman test statistic for general government
? consumption
? ------------------------------------------------------------------

--> Regress; Lhs= GGC ;
            Rhs = IV;  Str=Ind; Period=period; Fixed;
            Panel;  Res=Er       ? or Keep=YH
            $

+--------------------------------------------------------------------+
| OLS Without Group Dummy Variables                                  |
| Ordinary    least squares regression    Weighting variable = none  |
| Dep. var. = GGC      Mean=   16.15057391    , S.D.=   4.705923562  |
| Model size: Observations =     575, Parameters =  12, Deg.Fr.=   563 |
| Residuals:  Sum of squares= 427.9156358    , Std.Dev.=         .87182 |
| Fit:        R-squared=  .966337, Adjusted R-squared =          .96568 |
| Model test: F[ 11,    563] = 1469.22,    Prob value =          .00000 |
| Diagnostic: Log-L =   -730.9495, Restricted(b=0) Log-L =   -1705.9619 |
|             LogAmemiyaPrCrt.=    -.254, Akaike Info. Crt.=      2.584 |
| Panel Data Analysis of GGC        [ONE way]                          |
|           Unconditional ANOVA (No regressors)                        |
| Source      Variation        Deg. Free.     Mean Square              |
| Between       9520.75              15.         634.717               |
| Residual      3190.89             559.         5.70822               |
| Total         12711.6             574.         22.1457               |
+--------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDPEA       .4748210566        .13919691    3.411   .0006     9.6582452
 PTRADE   -.1912717097E-01 .38107250E-02   -5.019   .0000     63.954887
 LIFE         57.66322898        4.2114817   13.692   .0000     4.2999760
 RFERT        .8911971492        .30913450    2.883   .0039     2.0211209
 LINFLAT   .3225896269E-01 .81194892E-02    3.973   .0001     6.8524598
 LRGDINV   .2744920103E-01 .10374517E-01    2.646   .0081     23.417217
 LGGC         .9881645261   .10283868E-01   96.089   .0000     16.155026
 LTRADE    .1945835789E-01 .38006861E-02    5.120   .0000     64.061843
 LLIFE       -59.61014756        4.2563331  -14.005   .0000     4.2997550
 LRFERT      -.6380651252        .30652073   -2.082   .0374     2.0232078
 LURBAN    .2018840812E-02 .33555033E-02     .602   .5474     70.863826
 Constant     2.418900710        6.5589779     .369   .7123
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
```

Least Squares with Group Dummy Variables

Ordinary least squares regression Weighting variable = none

Dep. var. = GGC Mean= 16.15057391 , S.D.= 4.705923562

Model size: Observations = 575, Parameters = 27, Deg.Fr.= 548

Residuals: Sum of squares= 342.5470393 , Std.Dev.= .79062

Fit: R-squared= .973052, Adjusted R-squared = .97177

Model test: F[26, 548] = 761.07, Prob value = .00000

Diagnostic: Log-L = -666.9759, Restricted(b=0) Log-L = -1705.9619

LogAmemiyaPrCrt.= -.424, Akaike Info. Crt.= 2.414

Estd. Autocorrelation of e(i,t) .189580

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LGDPEA	1.637123772	.41175020	3.976	.0001	9.6582452
PTRADE	-.2593821041E-01	.58297995E-02	-4.449	.0000	63.954887
LIFE	44.85947218	5.0302175	8.918	.0000	4.2999760
RFERT	.5275181409	.29216947	1.806	.0710	2.0211209
LINFLAT	.3930479902E-01	.79750866E-02	4.928	.0000	6.8524598
LRGDINV	.1624988312E-01	.13453069E-01	1.208	.2271	23.417217
LGGC	.8014110656	.21139171E-01	37.911	.0000	16.155026
LTRADE	.1379339870E-01	.35799389E-02	3.853	.0001	64.061843
LLIFE	-50.52191085	4.1679139	-12.122	.0000	4.2997550
LRFERT	-.6390327905	.28335503	-2.255	.0241	2.0232078
LURBAN	.1503198895E-01	.98412578E-02	1.527	.1267	70.863826

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

Test Statistics for the Classical Model

	Model	Log-Likelihood	Sum of Squares	R-squared
(1)	Constant term only	-1705.96190	.1271164131D+05	.0000000
(2)	Group effects only	-1308.57432	.3190892187D+04	.7489787
(3)	X - variables only	-730.94951	.4279156358D+03	.9663367
(4)	X and group effects	-666.97586	.3425470393D+03	.9730525

Hypothesis Tests

	Likelihood Ratio Test			F Tests			
	Chi-squared	d.f.	Prob.	F	num.	denom.	Prob value
(2) vs (1)	794.775	15	.00000	111.194	15	559	.00000
(3) vs (1)	1950.025	11	.00000	1469.223	11	563	.00000
(4) vs (1)	2077.972	26	.00000	761.071	26	548	.00000
(4) vs (2)	1283.197	11	.00000	414.248	11	548	.00000
(4) vs (3)	127.947	15	.00000	9.105	15	548	.00000

```
+----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables and Period Effects          |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = GGC      Mean=   16.15057391    , S.D.=   4.705923562    |
| Model size: Observations =     575, Parameters =  62, Deg.Fr.=   513 |
| Residuals:  Sum of squares= 289.6832476    , Std.Dev.=         .75146 |
| Fit:        R-squared=  .977211, Adjusted R-squared =          .97450 |
| Model test: F[ 61,    513] =  360.62,    Prob value =          .00000 |
| Diagnostic: Log-L =   -618.7849, Restricted(b=0) Log-L =   -1705.9619 |
|             LogAmemiyaPrCrt.=    -.469, Akaike Info. Crt.=      2.368 |
| Estd. Autocorrelation of e(i,t)      .227507                         |
+----------------------------------------------------------------------+

+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDPEA       1.183390098       .50673915    2.335   .0195     9.6582452
 PTRADE   -.3826445228E-01  .63764789E-02   -6.001   .0000     63.954887
 LIFE        16.62281499       6.9683463    2.385   .0171     4.2999760
 RFERT        .9528748705       .29929344    3.184   .0015     2.0211209
 LINFLAT   .2933881200E-01  .10893866E-01    2.693   .0071     6.8524598
 LRGDINV  -.7138544593E-02  .14108920E-01    -.506   .6129     23.417217
 LGGC         .7957460896   .22839509E-01   34.841   .0000     16.155026
 LTRADE    .2559723968E-01  .41707839E-02    6.137   .0000     64.061843
 LLIFE      -18.84305034       6.5862617   -2.861   .0042     4.2997550
 LRFERT     -1.060479879       .29402867   -3.607   .0003     2.0232078
 LURBAN    .5592584632E-02  .98342298E-02     .569   .5696     70.863826
 Constant     2.005496048       16.503460     .122   .9033
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

+-----------------------------------------------------------------------+
|                Test Statistics for the Classical Model                |
|                                                                       |
|        Model             Log-Likelihood    Sum of Squares    R-squared |
| (1)  Constant term only    -1705.96190    .1271164131D+05     .0000000 |
| (2)  Group effects only    -1308.57432    .3190892187D+04     .7489787 |
| (3)  X - variables only     -730.94951    .4279156358D+03     .9663367 |
| (4)  X and group effects    -666.97586    .3425470393D+03     .9730525 |
| (5)  X ind.&time effects    -618.78484    .2896832476D+03     .9772112 |
|                                                                       |
|                          Hypothesis Tests                             |
|               Likelihood Ratio Test                 F Tests           |
|          Chi-squared   d.f.  Prob.          F    num. denom. Prob value |
| (2) vs (1)   794.775     15     .00000   111.194   15    559     .00000 |
| (3) vs (1)  1950.025     11     .00000  1469.223   11    563     .00000 |
| (4) vs (1)  2077.972     26     .00000   761.071   26    548     .00000 |
| (4) vs (2)  1283.197     11     .00000   414.248   11    548     .00000 |
| (4) vs (3)   127.947     15     .00000     9.105   15    548     .00000 |
| (5) vs (4)    96.382     35     .00000     2.675   35    513     .00000 |
| (5) vs (3)   224.329     51     .00000     4.800   51    513     .00000 |
+-----------------------------------------------------------------------+
```

```
--> Regress ;Lhs=Y;
            Rhs= X21,  Er;
            Str=Ind;
            Period=period;
            Fixed;
            RST Er=0;
            Panel $
```

```
+-----------------------------------------------------------------------+
| OLS Without Group Dummy Variables                                     |
| Ordinary    least squares regression    Weighting variable = none     |
| Dep. var. = RGDP     Mean=   2.920488278    , S.D.=   2.730104755     |
| Model size: Observations =     575, Parameters =  10, Deg.Fr.=    565 |
| Residuals:  Sum of squares= 2529.070731    , Std.Dev.=        2.11571 |
| Fit:        R-squared=  .408860, Adjusted R-squared =          .39944 |
| Model test: F[  9,    565] =   43.42,    Prob value =          .00000 |
| Diagnostic: Log-L =  -1241.7454, Restricted(b=0) Log-L =   -1392.8847 |
|             LogAmemiyaPrCrt.=    1.516, Akaike Info. Crt.=      4.354 |
| Panel Data Analysis of RGDP       [ONE way]                           |
|           Unconditional ANOVA (No regressors)                         |
| Source      Variation        Deg. Free.     Mean Square               |
| Between       301.508              15.         20.1005                |
| Residual      3976.79             559.         7.11411                |
| Total         4278.29             574.         7.45347                |
+-----------------------------------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LGDPEA	-2.367975649	.33413806	-7.087	.0000	9.6582452
INFLAT	-.2425735314	.19168186E-01	-12.655	.0000	6.8529990
RGDINV	.2464335660	.24966686E-01	9.870	.0000	23.430261
GGC	-.1196736546E-02	.25225716E-01	-.047	.9622	16.150574
PTRADE	.7481847648E-02	.24774994E-02	3.020	.0025	63.954887
LIFE	-4.367432086	3.7330373	-1.170	.2420	4.2999760
RFERT	-.5549764992	.22840247	-2.430	.0151	2.0211209
PURBAN	.1161671670E-01	.81405964E-02	1.427	.1536	70.838609
ER	-.2223523248	.85010141E-01	-2.616	.0089	-.11684903
Constant	40.27279258	15.625353	2.577	.0100	

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

```
+----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables                             |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = RGDP     Mean=   2.920488278    , S.D.=   2.730104755    |
| Model size: Observations =     575, Parameters =  25, Deg.Fr.=    550 |
| Residuals:  Sum of squares= 2156.103297    , Std.Dev.=        1.97995 |
| Fit:        R-squared=  .496037, Adjusted R-squared =          .47405 |
| Model test: F[ 24,    550] =   22.56,    Prob value =          .00000 |
| Diagnostic: Log-L =  -1195.8749, Restricted(b=0) Log-L =   -1392.8847 |
|             LogAmemiyaPrCrt.=    1.409, Akaike Info. Crt.=      4.247 |
| Estd. Autocorrelation of e(i,t)      .184608                         |
+----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDPEA      -3.311242017       1.0210964    -3.243   .0012     9.6582452
 INFLAT      -.2683047821    .20287764E-01  -13.225   .0000     6.8529990
 RGDINV       .2878429906    .34139590E-01    8.431   .0000     23.430261
 GGC         -.1607495825    .62302051E-01   -2.580   .0099     16.150574
 PTRADE    .8137139634E-01   .12218783E-01    6.660   .0000     63.954887
 LIFE        -15.09585031       8.8124557    -1.713   .0867     4.2999760
 RFERT       -1.097415764       .32816030    -3.344   .0008     2.0211209
 PURBAN    .4209946752E-01   .29850784E-01    1.410   .1584     70.838609
 ER          -.1249976116    .85234989E-01   -1.467   .1425    -.11684903
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

+----------------------------------------------------------------------+
|                Test Statistics for the Classical Model               |
|                                                                      |
|        Model             Log-Likelihood    Sum of Squares    R-squared |
| (1)  Constant term only     -1392.88471   .4278292912D+04     .0000000 |
| (2)  Group effects only     -1371.87411   .3976785128D+04     .0704739 |
| (3)  X - variables only     -1241.74534   .2529070731D+04     .4088598 |
| (4)  X and group effects    -1195.87490   .2156103297D+04     .4960365 |
|                                                                      |
|                            Hypothesis Tests                          |
|               Likelihood Ratio Test               F Tests            |
|          Chi-squared   d.f.  Prob.          F    num. denom. Prob value |
| (2) vs (1)    42.021     15     .00022     2.825    15    559     .00029 |
| (3) vs (1)   302.279      9     .00000    43.420     9    565     .00000 |
| (4) vs (1)   394.020     24     .00000    22.556    24    550     .00000 |
| (4) vs (2)   351.998      9     .00000    51.604     9    550     .00000 |
| (4) vs (3)    91.741     15     .00000     6.343    15    550     .00000 |
+----------------------------------------------------------------------+
```

```
+----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables and Period Effects          |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = RGDP     Mean=   2.920488278    , S.D.=   2.730104755    |
| Model size: Observations =     575, Parameters =  60, Deg.Fr.=   515 |
| Residuals:  Sum of squares= 1551.504043    , Std.Dev.=       1.73569 |
| Fit:        R-squared=  .637354, Adjusted R-squared =          .59581 |
| Model test: F[ 59,    515] =   15.34,     Prob value =         .00000 |
| Diagnostic: Log-L =  -1101.2651, Restricted(b=0) Log-L =   -1392.8847 |
|             LogAmemiyaPrCrt.=    1.202, Akaike Info. Crt.=      4.039 |
| Estd. Autocorrelation of e(i,t)      .142104                         |
+----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDPEA      -6.143508547       1.1594684    -5.299   .0000     9.6582452
 INFLAT      -.1924815145   .25101883E-01    -7.668   .0000     6.8529990
 RGDINV       .2654075229   .32901267E-01     8.067   .0000     23.430261
 GGC         -.1207466314   .66951563E-01    -1.803   .0713     16.150574
 PTRADE    .8365325834E-01  .12254662E-01     6.826   .0000     63.954887
 LIFE        -20.88862369       9.7275965    -2.147   .0318     4.2999760
 RFERT       -.6103109134       .30707514    -1.987   .0469     2.0211209
 PURBAN    .4834505897E-01  .27220587E-01     1.776   .0757     70.838609
 ER          -.3066216443       .11884223    -2.580   .0099    -.11684903
 Constant     141.5501692       37.461542     3.779   .0002
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

+----------------------------------------------------------------------+
|                 Test Statistics for the Classical Model               |
|                                                                       |
|         Model               Log-Likelihood    Sum of Squares    R-squared |
| (1)  Constant term only      -1392.88471   .4278292912D+04     .0000000 |
| (2)  Group effects only      -1371.87411   .3976785128D+04     .0704739 |
| (3)  X - variables only      -1241.74534   .2529070731D+04     .4088598 |
| (4)  X and group effects     -1195.87490   .2156103297D+04     .4960365 |
| (5)  X ind.&time effects     -1101.26505   .1551504043D+04     .6373544 |
|                                                                       |
|                              Hypothesis Tests                         |
|                Likelihood Ratio Test              F Tests             |
|           Chi-squared   d.f.   Prob.          F     num. denom. Prob value |
| (2) vs (1)     42.021     15     .00022      2.825    15   559     .00029 |
| (3) vs (1)    302.279      9     .00000     43.420     9   565     .00000 |
| (4) vs (1)    394.020     24     .00000     22.556    24   550     .00000 |
| (4) vs (2)    351.998      9     .00000     51.604     9   550     .00000 |
| (4) vs (3)     91.741     15     .00000      6.343    15   550     .00000 |
| (5) vs (4)    189.220     35     .00000      5.734    35   515     .00000 |
| (5) vs (3)    280.961     51     .00000      6.363    51   515     .00000 |
+----------------------------------------------------------------------+
--> Calc; list; LL0=LogL$
    LL0      = -.11012650466948630D+04
```

```
--> Regress ;Lhs=Y;
             Rhs=X21;
             Str=Ind;
             Period=period;
             Fixed;
             Panel $
```

```
+-----------------------------------------------------------------------+
| OLS Without Group Dummy Variables                                     |
| Ordinary    least squares regression    Weighting variable = none     |
| Dep. var. = RGDP     Mean=   2.923428403    , S.D.=   2.728642254     |
| Model size: Observations =     576, Parameters =   9, Deg.Fr.=    567 |
| Residuals:  Sum of squares= 2559.785135    , Std.Dev.=        2.12476 |
| Fit:        R-squared=  .402081, Adjusted R-squared =          .39364 |
| Model test: F[  8,    567] =   47.66,    Prob value =          .00000 |
| Diagnostic: Log-L =  -1246.8810, Restricted(b=0) Log-L =   -1394.9994 |
|             LogAmemiyaPrCrt.=    1.523, Akaike Info. Crt.=      4.361 |
| Panel Data Analysis of RGDP       [ONE way]                           |
|          Unconditional ANOVA (No regressors)                          |
| Source      Variation        Deg. Free.     Mean Square               |
| Between       300.599              15.         20.0399                |
| Residual      3980.56             560.         7.10814                |
| Total         4281.16             575.         7.44549                |
+-----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDPEA      -2.378869522       .33506420   -7.100   .0000     9.6576111
 INFLAT      -.2480965368   .19120869E-01  -12.975   .0000     6.8435319
 RGDINV       .2458873787   .25071319E-01    9.808   .0000     23.426389
 GGC      -.9339845527E-02  .25127287E-01    -.372   .7101     16.143889
 PTRADE    .7208001029E-02  .24858817E-02    2.900   .0037     63.987083
 LIFE        -4.944183290      3.7398291    -1.322   .1862     4.2999070
 RFERT       -.5403873250       .22930937   -2.357   .0184     2.0221085
 PURBAN    .1181958944E-01  .81328371E-02    1.453   .1461     70.876910
 Constant     43.03930508       15.638346    2.752   .0059
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
```

```
+-----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables                              |
| Ordinary    least squares regression    Weighting variable = none     |
| Dep. var. = RGDP     Mean=   2.923428403    , S.D.=   2.728642254     |
| Model size: Observations =     576, Parameters =  24, Deg.Fr.=    552 |
| Residuals:  Sum of squares= 2166.360550    , Std.Dev.=        1.98105 |
| Fit:        R-squared=  .493978, Adjusted R-squared =          .47289 |
| Model test: F[ 23,    552] =   23.43,    Prob value =          .00000 |
| Diagnostic: Log-L =  -1198.8211, Restricted(b=0) Log-L =   -1394.9994 |
|             LogAmemiyaPrCrt.=    1.408, Akaike Info. Crt.=      4.246 |
| Estd. Autocorrelation of e(i,t)     .185521                           |
+-----------------------------------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LGDPEA	-3.451555806	1.0159552	-3.397	.0007	9.6576111
INFLAT	-.2688656720	.20285087E-01	-13.254	.0000	6.8435319
RGDINV	.2846775653	.34102117E-01	8.348	.0000	23.426389
GGC	-.1898408097	.59262418E-01	-3.203	.0014	16.143889
PTRADE	.8108955241E-01	.12134754E-01	6.682	.0000	63.987083
LIFE	-13.87075805	8.7769884	-1.580	.1140	4.2999070
RFERT	-1.138165551	.32736350	-3.477	.0005	2.0221085
PURBAN	.4135041098E-01	.29753296E-01	1.390	.1646	70.876910

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

Test Statistics for the Classical Model

	Model	Log-Likelihood	Sum of Squares	R-squared
(1)	Constant term only	-1394.99935	.4281155915D+04	.0000000
(2)	Group effects only	-1374.03257	.3980556887D+04	.0702145
(3)	X - variables only	-1246.88103	.2559785135D+04	.4020808
(4)	X and group effects	-1198.82111	.2166360550D+04	.4939777

Hypothesis Tests

	Likelihood Ratio Test			F Tests			
	Chi-squared	d.f.	Prob.	F	num.	denom.	Prob value
(2) vs (1)	41.934	15	.00023	2.819	15	560	.00029
(3) vs (1)	296.237	8	.00000	47.661	8	567	.00000
(4) vs (1)	392.356	23	.00000	23.429	23	552	.00000
(4) vs (2)	350.423	8	.00000	57.783	8	552	.00000
(4) vs (3)	96.120	15	.00000	6.683	15	552	.00000

```
+----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables and Period Effects          |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = RGDP     Mean=    2.923428403    , S.D.=    2.728642254  |
| Model size: Observations =     576, Parameters =  59, Deg.Fr.=   517 |
| Residuals:  Sum of squares= 1579.264130    , Std.Dev.=       1.74776 |
| Fit:        R-squared=  .631113, Adjusted R-squared =         .58973 |
| Model test: F[ 58,    517] =   15.25,    Prob value =         .00000 |
| Diagnostic: Log-L =  -1107.7873, Restricted(b=0) Log-L =  -1394.9994 |
|             LogAmemiyaPrCrt.=    1.214, Akaike Info. Crt.=     4.051 |
| Estd. Autocorrelation of e(i,t)     .155076                          |
+----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDPEA      -6.180264289       1.1665175    -5.298   .0000     9.6576111
 INFLAT      -.1963587966   .25222341E-01    -7.785   .0000     6.8435319
 RGDINV       .2571240958   .32990621E-01     7.794   .0000     23.426389
 GGC         -.2038151656   .59428704E-01    -3.430   .0006     16.143889
 PTRADE    .7911324685E-01  .12210281E-01     6.479   .0000     63.987083
 LIFE        -22.27672987       9.7601218    -2.282   .0225     4.2999070
 RFERT       -.6449607403       .30891343    -2.088   .0368     2.0221085
 PURBAN    .5211116459E-01  .27329914E-01     1.907   .0566     70.876910
 Constant     149.5570293       37.519112     3.986   .0001
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

+-----------------------------------------------------------------------+
|                 Test Statistics for the Classical Model               |
|                                                                       |
|        Model              Log-Likelihood    Sum of Squares    R-squared |
| (1)  Constant term only     -1394.99935   .4281155915D+04     .0000000 |
| (2)  Group effects only     -1374.03257   .3980556887D+04     .0702145 |
| (3)  X - variables only     -1246.88103   .2559785135D+04     .4020808 |
| (4)  X and group effects    -1198.82111   .2166360550D+04     .4939777 |
| (5)  X ind.&time effects    -1107.78730   .1579264130D+04     .6311127 |
|                                                                       |
|                              Hypothesis Tests                         |
|                Likelihood Ratio Test               F Tests            |
|          Chi-squared   d.f.  Prob.          F    num. denom. Prob value |
| (2) vs (1)     41.934     15    .00023     2.819   15   560     .00029 |
| (3) vs (1)    296.237      8    .00000    47.661    8   567     .00000 |
| (4) vs (1)    392.356     23    .00000    23.429   23   552     .00000 |
| (4) vs (2)    350.423      8    .00000    57.783    8   552     .00000 |
| (4) vs (3)     96.120     15    .00000     6.683   15   552     .00000 |
| (5) vs (4)    182.068     35    .00000     5.491   35   517     .00000 |
| (5) vs (3)    278.187     51    .00000     6.294   51   517     .00000 |
+-----------------------------------------------------------------------+
--> Calc; list; LL1=LogL$
    LL1      = -.11077873016150570D+04


? Durbin-Wu-Hausman test (LR) for endogeneity

--> Calc; list; LR=2*(LL0-LL1)$
    LR       =  .13044509840387490D+02

--> Calc; list; Prob=1-Chi(LR, 1)$
    PROB     =  .30417475874744420D-03

--> Calc; list; ctb(0.95, 1)$
    Result   =  .38414591508300020D+01
```

```
? ---------------------------------------------------------------
? A JOINT Durbin-Wu-Hausman test statistic for inflation rate,
? investment ratio, and general government consumption
? ---------------------------------------------------------------

--> Regress; Lhs= Inflat ;
             Rhs = IV;  Str=Ind; Period=period; Fixed;
             Panel;  Res=Er1;        ? or Keep=YH1
             Output=5$

+----------------------------------------------------------------------+
| OLS Without Group Dummy Variables                                    |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = INFLAT   Mean=   6.852998957    , S.D.=   5.399438779    |
| Model size: Observations =     575, Parameters =  12, Deg.Fr.=   563 |
| Residuals:  Sum of squares= 3818.827912    , Std.Dev.=       2.60442 |
| Fit:        R-squared=  .771797, Adjusted R-squared =         .76734 |
| Model test: F[ 11,    563] =  173.10,    Prob value =         .00000 |
| Diagnostic: Log-L =  -1360.2217, Restricted(b=0) Log-L =  -1785.0089 |
|             LogAmemiyaPrCrt.=    1.935, Akaike Info. Crt.=     4.773 |
| Panel Data Analysis of INFLAT      [ONE way]                         |
|           Unconditional ANOVA (No regressors)                        |
| Source      Variation        Deg. Free.     Mean Square              |
| Between       3637.56              15.         242.504               |
| Residual      13096.8             559.         23.4290               |
| Total         16734.4             574.         29.1539               |
+----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDPEA      -.9111364010       .41582977    -2.191   .0284    9.6582452
 PTRADE    .2299861130E-01  .11383965E-01    2.020   .0434    63.954887
 LIFE        -10.03031237       12.581166    -.797   .4253    4.2999760
 RFERT        .2836987170       .92349265     .307   .7587    2.0211209
 LINFLAT      .8110187008   .24255748E-01   33.436   .0000    6.8524598
 LRGDINV      .1730198035   .30992302E-01    5.583   .0000    23.417217
 LGGC      .5260546836E-01  .30721502E-01    1.712   .0868    16.155026
 LTRADE   -.1967132254E-01  .11353976E-01   -1.733   .0832    64.061843
 LLIFE        9.245091421       12.715153     .727   .4672    4.2997550
 LRFERT      -.1413166344       .91568440    -.154   .8774    2.0232078
 LURBAN    .8664624104E-02  .10024059E-01     .864   .3874    70.863826
 Constant     7.460316699       19.593956     .381   .7034
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
```

```
+----------------------------------------------------------------------------+
| Least Squares with Group Dummy Variables                                   |
| Ordinary    least squares regression    Weighting variable = none          |
| Dep. var. = INFLAT   Mean=   6.852998957    , S.D.=   5.399438779          |
| Model size: Observations =     575, Parameters =  27, Deg.Fr.=     548     |
| Residuals:  Sum of squares= 3376.263435    , Std.Dev.=         2.48215     |
| Fit:        R-squared=  .798244, Adjusted R-squared =           .78867     |
| Model test: F[ 26,    548] =   83.39,    Prob value =           .00000     |
| Diagnostic: Log-L =  -1324.8092, Restricted(b=0) Log-L =   -1785.0089      |
|             LogAmemiyaPrCrt.=    1.864, Akaike Info. Crt.=      4.702      |
| Estd. Autocorrelation of e(i,t)     .048457                                |
+----------------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDPEA       5.070180408        1.2926825    3.922   .0001     9.6582452
 PTRADE    .6631503349E-01  .18302553E-01    3.623   .0003     63.954887
 LIFE        -74.43986140        15.792279   -4.714   .0000     4.2999760
 RFERT        .4530672527        .91726092     .494   .6214     2.0211209
 LINFLAT      .7543353024   .25037644E-01   30.128   .0000     6.8524598
 LRGDINV      .2604320411   .42235673E-01    6.166   .0000     23.417217
 LGGC     -.3113430923E-01  .66366055E-01    -.469   .6390     16.155026
 LTRADE   -.1121934904E-01  .11239155E-01    -.998   .3182     64.061843
 LLIFE        34.23654302        13.085092    2.616   .0089     4.2997550
 LRFERT       .2093796702        .88958813     .235   .8139     2.0232078
 LURBAN   -.6066563302E-01  .30896456E-01   -1.964   .0496     70.863826
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

+----------------------------------------------------------------------------+
|                 Test Statistics for the Classical Model                    |
|                                                                            |
|        Model             Log-Likelihood    Sum of Squares    R-squared     |
| (1)  Constant term only    -1785.00886   .1673436106D+05     .0000000      |
| (2)  Group effects only    -1714.54371   .1309680075D+05     .2173707      |
| (3)  X - variables only    -1360.22168   .3818827912D+04     .7717972      |
| (4)  X and group effects   -1324.80918   .3376263435D+04     .7982437      |
|                                                                            |
|                            Hypothesis Tests                                |
|                 Likelihood Ratio Test                F Tests               |
|            Chi-squared   d.f.  Prob.          F     num. denom. Prob value |
| (2) vs (1)    140.930     15     .00000     10.351    15    559     .00000 |
| (3) vs (1)    849.574     11     .00000    173.100    11    563     .00000 |
| (4) vs (1)    920.399     26     .00000     83.390    26    548     .00000 |
| (4) vs (2)    779.469     11     .00000    143.431    11    548     .00000 |
| (4) vs (3)     70.825     15     .00000      4.789    15    548     .00000 |
+----------------------------------------------------------------------------+
```

```
Least Squares with Group Dummy Variables and Period Effects
Ordinary    least squares regression    Weighting variable = none
Dep. var. = INFLAT   Mean=    6.852998957    , S.D.=    5.399438779
Model size: Observations =      575, Parameters =  62, Deg.Fr.=    513
Residuals:  Sum of squares= 2228.003322    , Std.Dev.=        2.08401
Fit:        R-squared=  .866861, Adjusted R-squared =          .85103
Model test: F[ 61,     513] =   54.76,     Prob value =          .00000
Diagnostic: Log-L =  -1205.3058, Restricted(b=0) Log-L =   -1785.0089
            LogAmemiyaPrCrt.=    1.571, Akaike Info. Crt.=      4.408
Estd. Autocorrelation of e(i,t)     -.001190
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LGDPEA	1.310780860	1.4053377	.933	.3510	9.6582452
PTRADE	.4835885765E-02	.17683864E-01	.273	.7845	63.954887
LIFE	-19.88917789	19.325287	-1.029	.3034	4.2999760
RFERT	-.7349449401	.83002929	-.885	.3759	2.0211209
LINFLAT	.6760018848	.30211916E-01	22.375	.0000	6.8524598
LRGDINV	.1888736296	.39128210E-01	4.827	.0000	23.417217
LGGC	-.4014483802E-01	.63340719E-01	-.634	.5262	16.155026
LTRADE	.8247601519E-02	.11566818E-01	.713	.4758	64.061843
LLIFE	16.93262603	18.265653	.927	.3539	4.2997550
LRFERT	1.791946288	.81542855	2.198	.0280	2.0232078
LURBAN	-.6564084152E-01	.27273230E-01	-2.407	.0161	70.863826
Constant	.1772293782	45.768981	.004	.9969	

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

Test Statistics for the Classical Model

	Model	Log-Likelihood	Sum of Squares	R-squared
(1)	Constant term only	-1785.00886	.1673436106D+05	.0000000
(2)	Group effects only	-1714.54371	.1309680075D+05	.2173707
(3)	X - variables only	-1360.22168	.3818827912D+04	.7717972
(4)	X and group effects	-1324.80918	.3376263435D+04	.7982437
(5)	X ind.&time effects	-1205.30583	.2228003322D+04	.8668606

Hypothesis Tests

	Likelihood Ratio Test			F Tests			
	Chi-squared	d.f.	Prob.	F	num.	denom.	Prob value
(2) vs (1)	140.930	15	.00000	10.351	15	559	.00000
(3) vs (1)	849.574	11	.00000	173.100	11	563	.00000
(4) vs (1)	920.399	26	.00000	83.390	26	548	.00000
(4) vs (2)	779.469	11	.00000	143.431	11	548	.00000
(4) vs (3)	70.825	15	.00000	4.789	15	548	.00000
(5) vs (4)	239.007	35	.00000	7.554	35	513	.00000
(5) vs (3)	309.832	51	.00000	7.182	51	513	.00000

```
--> Regress; Lhs= RGDINV ;
            Rhs = IV;  Str=Ind; Period=period; Fixed;
            Panel;  Res=Er2;       ? or Keep=YH2
            Output=5$
```

```
+-------------------------------------------------------------------+
| OLS Without Group Dummy Variables                                 |
| Ordinary    least squares regression    Weighting variable = none |
| Dep. var. = RGDINV   Mean=   23.43026087    , S.D.=   4.881575519 |
| Model size: Observations =     575, Parameters =  12, Deg.Fr.=    563 |
| Residuals:  Sum of squares= 2306.428964    , Std.Dev.=       2.02402 |
| Fit:        R-squared=  .831380, Adjusted R-squared =         .82809 |
| Model test: F[ 11,    563] =  252.35,    Prob value =         .00000 |
| Diagnostic: Log-L =  -1215.2518, Restricted(b=0) Log-L =   -1727.0333 |
|             LogAmemiyaPrCrt.=    1.431, Akaike Info. Crt.=     4.269 |
| Panel Data Analysis of RGDINV     [ONE way]                       |
|           Unconditional ANOVA (No regressors)                     |
| Source      Variation       Deg. Free.     Mean Square            |
| Between       6431.56              15.        428.771             |
| Residual      7246.73             559.        12.9637             |
| Total         13678.3             574.        23.8298             |
+-------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDPEA   -.5884579682E-01     .32316221    -.182   .8555     9.6582452
 PTRADE   -.4282229788E-02 .88470518E-02    -.484   .6284     63.954887
 LIFE        -55.94422416      9.7774562   -5.722   .0000     4.2999760
 RFERT       -1.398096327      .71769256   -1.948   .0514     2.0211209
 LINFLAT  -.8464290204E-01 .18850361E-01   -4.490   .0000     6.8524598
 LRGDINV      .8589405506  .24085676E-01   35.662   .0000     23.417217
 LGGC     -.8942756245E-01 .23875223E-01   -3.746   .0002     16.155026
 LTRADE   -.4441174395E-03 .88237455E-02    -.050   .9599     64.061843
 LLIFE        51.99032397      9.8815841    5.261   .0000     4.2997550
 LRFERT       1.215792396      .71162437    1.708   .0875     2.0232078
 LURBAN   -.1293745686E-01 .77902004E-02   -1.661   .0968     70.863826
 Constant     24.50753196      15.227448    1.609   .1075
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
```

Least Squares with Group Dummy Variables

Ordinary least squares regression Weighting variable = none

Dep. var. = RGDINV Mean= 23.43026087 , S.D.= 4.881575519

Model size: Observations = 575, Parameters = 27, Deg.Fr.= 548

Residuals: Sum of squares= 2090.521004 , Std.Dev.= 1.95316

Fit: R-squared= .847165, Adjusted R-squared = .83991

Model test: F[26, 548] = 116.83, Prob value = .00000

Diagnostic: Log-L = -1186.9943, Restricted(b=0) Log-L = -1727.0333

LogAmemiyaPrCrt.= 1.385, Akaike Info. Crt.= 4.223

Estd. Autocorrelation of e(i,t) .109596

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LGDPEA	-.7135715628	1.0171874	-.702	.4830	9.6582452
PTRADE	.4077827070E-01	.14401933E-01	2.831	.0046	63.954887
LIFE	-56.06831937	12.426646	-4.512	.0000	4.2999760
RFERT	-.9339705028	.72177527	-1.294	.1957	2.0211209
LINFLAT	-.5097478995E-01	.19701648E-01	-2.587	.0097	6.8524598
LRGDINV	.7234775610	.33234452E-01	21.769	.0000	23.417217
LGGC	-.2433119535	.52222193E-01	-4.659	.0000	16.155026
LTRADE	-.6011768660E-02	.88438787E-02	-.680	.4967	64.061843
LLIFE	48.04326173	10.296412	4.666	.0000	4.2997550
LRFERT	1.154928604	.70000007	1.650	.0990	2.0232078
LURBAN	.7749068047E-02	.24311837E-01	.319	.7499	70.863826

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

Test Statistics for the Classical Model

	Model	Log-Likelihood	Sum of Squares	R-squared
(1)	Constant term only	-1727.03333	.1367829346D+05	.0000000
(2)	Group effects only	-1544.39629	.7246733802D+04	.4702019
(3)	X - variables only	-1215.25179	.2306428964D+04	.8313804
(4)	X and group effects	-1186.99424	.2090521004D+04	.8471651

Hypothesis Tests

	Likelihood Ratio Test			F Tests			
	Chi-squared	d.f.	Prob.	F	num.	denom.	Prob value
(2) vs (1)	365.274	15	.00000	33.075	15	559	.00000
(3) vs (1)	1023.563	11	.00000	252.352	11	563	.00000
(4) vs (1)	1080.078	26	.00000	116.830	26	548	.00000
(4) vs (2)	714.804	11	.00000	122.875	11	548	.00000
(4) vs (3)	56.515	15	.00000	3.773	15	548	.00000

```
+----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables and Period Effects          |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = RGDINV   Mean=   23.43026087     , S.D.=   4.881575519   |
| Model size: Observations =      575, Parameters =  62, Deg.Fr.=    513 |
| Residuals:  Sum of squares= 1494.961031     , Std.Dev.=        1.70709 |
| Fit:        R-squared=  .890706, Adjusted R-squared =           .87771 |
| Model test: F[ 61,     513] =   68.54,    Prob value =          .00000 |
| Diagnostic: Log-L =  -1090.5917, Restricted(b=0) Log-L =  -1727.0333 |
|             LogAmemiyaPrCrt.=    1.172, Akaike Info. Crt.=      4.009 |
| Estd. Autocorrelation of e(i,t)     .124121                           |
+----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDPEA      -1.147551974       1.1511653     -.997   .3188     9.6582452
 PTRADE    .4660796823E-01  .14485523E-01     3.218   .0013     63.954887
 LIFE         27.62452592       15.830075     1.745   .0810     4.2999760
 RFERT       -2.428323214       .67990845    -3.572   .0004     2.0211209
 LINFLAT  -.7746489426E-01  .24747725E-01    -3.130   .0017     6.8524598
 LRGDINV      .7239477204   .32051400E-01    22.587   .0000     23.417217
 LGGC        -.2248644786   .51884783E-01    -4.334   .0000     16.155026
 LTRADE   -.1948901341E-01  .94748192E-02    -2.057   .0397     64.061843
 LLIFE       -14.60467736       14.962089     -.976   .3290     4.2997550
 LRFERT       2.988971638       .66794843     4.475   .0000     2.0232078
 LURBAN    .1658355446E-01  .22340536E-01      .742   .4579     70.863826
 Constant    -38.31084511       37.491107    -1.022   .3068
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)


+-----------------------------------------------------------------------+
|                Test Statistics for the Classical Model                |
|                                                                       |
|        Model              Log-Likelihood    Sum of Squares    R-squared |
|                                                                       |
| (1)   Constant term only    -1727.03333   .1367829346D+05     .0000000 |
| (2)   Group effects only    -1544.39629   .7246733802D+04     .4702019 |
| (3)   X - variables only    -1215.25179   .2306428964D+04     .8313804 |
| (4)   X and group effects   -1186.99424   .2090521004D+04     .8471651 |
| (5)   X ind.&time effects   -1090.59170   .1494961031D+04     .8907056 |
|                                                                       |
|                            Hypothesis Tests                          |
|               Likelihood Ratio Test                  F Tests          |
|          Chi-squared   d.f.  Prob.          F     num.  denom. Prob value |
| (2) vs (1)   365.274      15      .00000    33.075   15    559     .00000 |
| (3) vs (1)  1023.563      11      .00000   252.352   11    563     .00000 |
| (4) vs (1)  1080.078      26      .00000   116.830   26    548     .00000 |
| (4) vs (2)   714.804      11      .00000   122.875   11    548     .00000 |
| (4) vs (3)    56.515      15      .00000     3.773   15    548     .00000 |
| (5) vs (4)   192.805      35      .00000     5.839   35    513     .00000 |
| (5) vs (3)   249.320      51      .00000     5.460   51    513     .00000 |
+-----------------------------------------------------------------------+
```

```
--> Regress; Lhs= GGC ;
             Rhs = IV;  Str=Ind; Period=period; Fixed;
             Panel;  Res=Er3;       ? or Keep=YH3
             Output=5$
```

```
+-------------------------------------------------------------------------+
| OLS Without Group Dummy Variables                                       |
| Ordinary    least squares regression    Weighting variable = none       |
| Dep. var. = GGC      Mean=    16.15057391    , S.D.=    4.705923562     |
| Model size: Observations =      575, Parameters =  12, Deg.Fr.=     563 |
| Residuals:  Sum of squares= 427.9156358    , Std.Dev.=          .87182  |
| Fit:        R-squared=  .966337, Adjusted R-squared =           .96568  |
| Model test: F[ 11,     563] = 1469.22,     Prob value =          .00000  |
| Diagnostic: Log-L =    -730.9495, Restricted(b=0) Log-L =    -1705.9619 |
|             LogAmemiyaPrCrt.=    -.254, Akaike Info. Crt.=      2.584   |
| Panel Data Analysis of GGC        [ONE way]                             |
|           Unconditional ANOVA (No regressors)                           |
| Source      Variation        Deg. Free.     Mean Square                 |
| Between       9520.75             15.          634.717                  |
| Residual      3190.89            559.          5.70822                  |
| Total         12711.6            574.          22.1457                  |
+-------------------------------------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LGDPEA	.4748210566	.13919691	3.411	.0006	9.6582452
PTRADE	-.1912717097E-01	.38107250E-02	-5.019	.0000	63.954887
LIFE	57.66322898	4.2114817	13.692	.0000	4.2999760
RFERT	.8911971492	.30913450	2.883	.0039	2.0211209
LINFLAT	.3225896269E-01	.81194892E-02	3.973	.0001	6.8524598
LRGDINV	.2744920103E-01	.10374517E-01	2.646	.0081	23.417217
LGGC	.9881645261	.10283868E-01	96.089	.0000	16.155026
LTRADE	.1945835789E-01	.38006861E-02	5.120	.0000	64.061843
LLIFE	-59.61014756	4.2563331	-14.005	.0000	4.2997550
LRFERT	-.6380651252	.30652073	-2.082	.0374	2.0232078
LURBAN	.2018840812E-02	.33555033E-02	.602	.5474	70.863826
Constant	2.418900710	6.5589779	.369	.7123	

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

```
+-------------------------------------------------------------------------+
| Least Squares with Group Dummy Variables                                |
| Ordinary    least squares regression    Weighting variable = none       |
| Dep. var. = GGC      Mean=   16.15057391    , S.D.=   4.705923562       |
| Model size: Observations =     575, Parameters =  27, Deg.Fr.=    548   |
| Residuals:  Sum of squares= 342.5470393    , Std.Dev.=         .79062   |
| Fit:        R-squared=  .973052, Adjusted R-squared =          .97177   |
| Model test: F[ 26,    548] =  761.07,    Prob value =          .00000   |
| Diagnostic: Log-L =    -666.9759, Restricted(b=0) Log-L =   -1705.9619  |
|             LogAmemiyaPrCrt.=    -.424, Akaike Info. Crt.=      2.414   |
| Estd. Autocorrelation of e(i,t)     .189580                             |
+-------------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDPEA       1.637123772        .41175020    3.976   .0001     9.6582452
 PTRADE   -.2593821041E-01  .58297995E-02   -4.449   .0000     63.954887
 LIFE        44.85947218         5.0302175    8.918   .0000     4.2999760
 RFERT        .5275181409        .29216947    1.806   .0710     2.0211209
 LINFLAT   .3930479902E-01  .79750866E-02    4.928   .0000     6.8524598
 LRGDINV   .1624988312E-01  .13453069E-01    1.208   .2271     23.417217
 LGGC         .8014110656   .21139171E-01   37.911   .0000     16.155026
 LTRADE    .1379339870E-01  .35799389E-02    3.853   .0001     64.061843
 LLIFE       -50.52191085        4.1679139  -12.122   .0000     4.2997550
 LRFERT      -.6390327905        .28335503   -2.255   .0241     2.0232078
 LURBAN    .1503198895E-01  .98412578E-02    1.527   .1267     70.863826
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

+-------------------------------------------------------------------------+
|                 Test Statistics for the Classical Model                 |
|                                                                         |
|        Model             Log-Likelihood    Sum of Squares    R-squared  |
| (1)  Constant term only    -1705.96190   .1271164131D+05     .0000000  |
| (2)  Group effects only    -1308.57432   .3190892187D+04     .7489787  |
| (3)  X - variables only     -730.94951   .4279156358D+03     .9663367  |
| (4)  X and group effects    -666.97586   .3425470393D+03     .9730525  |
|                                                                         |
|                                Hypothesis Tests                         |
|                Likelihood Ratio Test                F Tests             |
|           Chi-squared   d.f.  Prob.           F    num. denom. Prob value |
| (2) vs (1)    794.775     15      .00000   111.194   15   559      .00000 |
| (3) vs (1)   1950.025     11      .00000  1469.223   11   563      .00000 |
| (4) vs (1)   2077.972     26      .00000   761.071   26   548      .00000 |
| (4) vs (2)   1283.197     11      .00000   414.248   11   548      .00000 |
| (4) vs (3)    127.947     15      .00000     9.105   15   548      .00000 |
+-------------------------------------------------------------------------+
```

```
+----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables and Period Effects          |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = GGC      Mean=   16.15057391    , S.D.=    4.705923562   |
| Model size: Observations =      575, Parameters =  62, Deg.Fr.=   513 |
| Residuals:  Sum of squares= 289.6832476     , Std.Dev.=        .75146 |
| Fit:        R-squared=  .977211, Adjusted R-squared =          .97450 |
| Model test: F[ 61,    513] =  360.62,     Prob value =          .00000 |
| Diagnostic: Log-L =    -618.7849, Restricted(b=0) Log-L =  -1705.9619 |
|             LogAmemiyaPrCrt.=     -.469, Akaike Info. Crt.=      2.368 |
| Estd. Autocorrelation of e(i,t)      .227507                         |
+----------------------------------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LGDPEA	1.183390098	.50673915	2.335	.0195	9.6582452
PTRADE	-.3826445228E-01	.63764789E-02	-6.001	.0000	63.954887
LIFE	16.62281499	6.9683463	2.385	.0171	4.2999760
RFERT	.9528748705	.29929344	3.184	.0015	2.0211209
LINFLAT	.2933881200E-01	.10893866E-01	2.693	.0071	6.8524598
LRGDINV	-.7138544593E-02	.14108920E-01	-.506	.6129	23.417217
LGGC	.7957460896	.22839509E-01	34.841	.0000	16.155026
LTRADE	.2559723968E-01	.41707839E-02	6.137	.0000	64.061843
LLIFE	-18.84305034	6.5862617	-2.861	.0042	4.2997550
LRFERT	-1.060479879	.29402867	-3.607	.0003	2.0232078
LURBAN	.5592584632E-02	.98342298E-02	.569	.5696	70.863826
Constant	2.005496048	16.503460	.122	.9033	

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

Test Statistics for the Classical Model

	Model	Log-Likelihood	Sum of Squares	R-squared
(1)	Constant term only	-1705.96190	.1271164131D+05	.0000000
(2)	Group effects only	-1308.57432	.3190892187D+04	.7489787
(3)	X - variables only	-730.94951	.4279156358D+03	.9663367
(4)	X and group effects	-666.97586	.3425470393D+03	.9730525
(5)	X ind.&time effects	-618.78484	.2896832476D+03	.9772112

Hypothesis Tests

	Likelihood Ratio Test			F Tests			
	Chi-squared	d.f.	Prob.	F	num.	denom.	Prob value
(2) vs (1)	794.775	15	.00000	111.194	15	559	.00000
(3) vs (1)	1950.025	11	.00000	1469.223	11	563	.00000
(4) vs (1)	2077.972	26	.00000	761.071	26	548	.00000
(4) vs (2)	1283.197	11	.00000	414.248	11	548	.00000
(4) vs (3)	127.947	15	.00000	9.105	15	548	.00000
(5) vs (4)	96.382	35	.00000	2.675	35	513	.00000
(5) vs (3)	224.329	51	.00000	4.800	51	513	.00000

```
--> Regress ;Lhs=Y;
            Rhs= X21, Er1, Er2, Er3;
            Str=Ind;
            Period=period;
            Fixed;
            RST Er1=Er2=Er3=0;
            Panel $
```

```
+-----------------------------------------------------------------------+
| OLS Without Group Dummy Variables                                     |
| Ordinary    least squares regression    Weighting variable = none     |
| Dep. var. = RGDP     Mean=   2.920488278    , S.D.=   2.730104755     |
| Model size: Observations =     575, Parameters =  12, Deg.Fr.=    563 |
| Residuals:  Sum of squares= 2489.799126    , Std.Dev.=        2.10295 |
| Fit:        R-squared=  .418039, Adjusted R-squared =          .40667 |
| Model test: F[ 11,    563] =   36.77,    Prob value =          .00000 |
| Diagnostic: Log-L =  -1237.2460, Restricted(b=0) Log-L =   -1392.8847 |
|             LogAmemiyaPrCrt.=    1.507, Akaike Info. Crt.=      4.345 |
| Panel Data Analysis of RGDP       [ONE way]                           |
|           Unconditional ANOVA (No regressors)                         |
| Source      Variation        Deg. Free.     Mean Square               |
| Between       301.508              15.         20.1005                |
| Residual      3976.79             559.         7.11411                |
| Total         4278.29             574.         7.45347                |
+-----------------------------------------------------------------------+
+---------+-------------+---------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+-------------+---------------+--------+---------+----------+
 LGDPEA      -2.086337232       .34533482    -6.041   .0000     9.6582452
 INFLAT      -.2152736496    .21860178E-01   -9.848   .0000     6.8529990
 RGDINV       .2089663731    .28123350E-01    7.430   .0000     23.430261
 GGC       -.2521436506E-01  .26453394E-01    -.953   .3405     16.150574
 PTRADE     .6386473197E-02  .24987580E-02    2.556   .0106     63.954887
 LIFE        -5.297038777       3.7236038    -1.423   .1549     4.2999760
 RFERT       -.5016728939       .22810403    -2.199   .0279     2.0211209
 PURBAN     .8621447757E-02  .81863305E-02    1.053   .2923     70.838609
 ER1       -.9220854608E-01  .39386724E-01   -2.341   .0192  .39698912E-01
 ER2          .1243171223    .48136111E-01    2.583   .0098     .26061102
 ER3       -.6939420606E-01     .10592233     -.655   .5124    -.11684903
 Constant     42.79226209       15.557047     2.751   .0059
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
```

```
+----------------------------------------------------------------------------+
| Least Squares with Group Dummy Variables                                   |
| Ordinary    least squares regression    Weighting variable = none          |
| Dep. var. = RGDP     Mean=   2.920488278    , S.D.=   2.730104755          |
| Model size: Observations =     575, Parameters =  27, Deg.Fr.=     548     |
| Residuals:  Sum of squares= 2120.852810    , Std.Dev.=        1.96727      |
| Fit:        R-squared=  .504276, Adjusted R-squared =          .48076      |
| Model test: F[ 26,    548] =   21.44,    Prob value =          .00000      |
| Diagnostic: Log-L =  -1191.1357, Restricted(b=0) Log-L =   -1392.8847      |
|             LogAmemiyaPrCrt.=    1.399, Akaike Info. Crt.=      4.237      |
| Estd. Autocorrelation of e(i,t)     .187611                                |
+----------------------------------------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LGDPEA	-3.104752776	1.0408770	-2.983	.0029	9.6582452
INFLAT	-.2249413031	.24957269E-01	-9.013	.0000	6.8529990
RGDINV	.2073433508	.44949175E-01	4.613	.0000	23.430261
GGC	-.2492290140	.70592825E-01	-3.531	.0004	16.150574
PTRADE	.8174306115E-01	.12220841E-01	6.689	.0000	63.954887
LIFE	-16.63345802	8.9400827	-1.861	.0628	4.2999760
RFERT	-1.029275050	.32717391	-3.146	.0017	2.0211209
PURBAN	.5039677328E-01	.29821547E-01	1.690	.0910	70.838609
ER1	-.1053828383	.39659932E-01	-2.657	.0079	.39698912E-01
ER2	.1320802972	.53301355E-01	2.478	.0132	.26061102
ER3	.6231260836E-01	.11600201	.537	.5912	-.11684903

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

Test Statistics for the Classical Model

	Model	Log-Likelihood	Sum of Squares	R-squared
(1)	Constant term only	-1392.88471	.4278292912D+04	.0000000
(2)	Group effects only	-1371.87411	.3976785128D+04	.0704739
(3)	X - variables only	-1237.24600	.2489799126D+04	.4180391
(4)	X and group effects	-1191.13567	.2120852810D+04	.5042759

Hypothesis Tests

	Likelihood Ratio Test			F Tests			
	Chi-squared	d.f.	Prob.	F	num.	denom.	Prob value
(2) vs (1)	42.021	15	.00022	2.825	15	559	.00029
(3) vs (1)	311.277	11	.00000	36.765	11	563	.00000
(4) vs (1)	403.498	26	.00000	21.441	26	548	.00000
(4) vs (2)	361.477	11	.00000	43.595	11	548	.00000
(4) vs (3)	92.221	15	.00000	6.355	15	548	.00000

```
+----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables and Period Effects          |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = RGDP     Mean=   2.920488278    , S.D.=   2.730104755    |
| Model size: Observations =     575, Parameters =  62, Deg.Fr.=   513 |
| Residuals:  Sum of squares= 1351.342407    , Std.Dev.=       1.62302 |
| Fit:        R-squared=  .684140, Adjusted R-squared =         .64658 |
| Model test: F[ 61,    513] =   18.22,    Prob value =         .00000 |
| Diagnostic: Log-L =  -1061.5537, Restricted(b=0) Log-L =  -1392.8847 |
|             LogAmemiyaPrCrt.=    1.071, Akaike Info. Crt.=     3.908 |
| Estd. Autocorrelation of e(i,t)     .090747                          |
+----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDPEA      -4.714649497       1.0968215    -4.298   .0000     9.6582452
 INFLAT      -.1848417820    .32326981E-01   -5.718   .0000     6.8529990
 RGDINV    .1027977630E-01   .44243012E-01     .232   .8163     23.430261
 GGC         -.2751517686    .65300030E-01   -4.214   .0000     16.150574
 PTRADE    .9098473440E-01   .11491245E-01    7.918   .0000     63.954887
 LIFE        -19.24914306       9.1337396    -2.107   .0351     4.2999760
 RFERT       -.2742757911        .29086530    -.943   .3457     2.0211209
 PURBAN    .5876103572E-01   .25578817E-01    2.297   .0216     70.838609
 ER1       .4318687122E-01   .47228125E-01     .914   .3605  .39698912E-01
 ER2          .5073635225    .60584454E-01    8.374   .0000      .26061102
 ER3         -.1286671380        .11350940   -1.134   .2570    -.11684903
 Constant     127.1202071       35.228730     3.608   .0003
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

+-----------------------------------------------------------------------+
|                 Test Statistics for the Classical Model                |
|                                                                        |
|         Model             Log-Likelihood    Sum of Squares    R-squared |
| (1)  Constant term only     -1392.88471   .4278292912D+04     .0000000 |
| (2)  Group effects only     -1371.87411   .3976785128D+04     .0704739 |
| (3)  X - variables only     -1237.24600   .2489799126D+04     .4180391 |
| (4)  X and group effects    -1191.13567   .2120852810D+04     .5042759 |
| (5)  X ind.&time effects    -1061.55372   .1351342407D+04     .6841398 |
|                                                                        |
|                                Hypothesis Tests                        |
|                 Likelihood Ratio Test                F Tests           |
|            Chi-squared   d.f.  Prob.          F     num. denom. Prob value |
| (2) vs (1)     42.021      15     .00022      2.825   15    559     .00029 |
| (3) vs (1)    311.277      11     .00000     36.765   11    563     .00000 |
| (4) vs (1)    403.498      26     .00000     21.441   26    548     .00000 |
| (4) vs (2)    361.477      11     .00000     43.595   11    548     .00000 |
| (4) vs (3)     92.221      15     .00000      6.355   15    548     .00000 |
| (5) vs (4)    259.164      35     .00000      8.346   35    513     .00000 |
| (5) vs (3)    351.385      51     .00000      8.474   51    513     .00000 |
+-----------------------------------------------------------------------+

--> Calc; list; Sumsq0=sumsqdev$
    Sumsq0  = 1351.342407

--> Calc; list; LL0=LogL$
    LL0     = -.10615537248262430D+04
```

```
--> Regress ;Lhs=Y;
            Rhs=X21;
            Str=Ind;
            Period=period;
            Fixed;
            Panel $
```

```
+-----------------------------------------------------------------------+
| OLS Without Group Dummy Variables                                     |
| Ordinary    least squares regression    Weighting variable = none     |
| Dep. var. = RGDP     Mean=   2.923428403    , S.D.=    2.728642254    |
| Model size: Observations =      576, Parameters =   9, Deg.Fr.=   567 |
| Residuals:  Sum of squares= 2559.785135    , Std.Dev.=        2.12476 |
| Fit:        R-squared=  .402081, Adjusted R-squared =          .39364 |
| Model test: F[  8,    567] =   47.66,    Prob value =          .00000 |
| Diagnostic: Log-L =  -1246.8810, Restricted(b=0) Log-L =   -1394.9994 |
|             LogAmemiyaPrCrt.=    1.523, Akaike Info. Crt.=      4.361 |
| Panel Data Analysis of RGDP       [ONE way]                           |
|           Unconditional ANOVA (No regressors)                         |
| Source      Variation       Deg. Free.     Mean Square                |
| Between       300.599             15.         20.0399                 |
| Residual      3980.56            560.         7.10814                 |
| Total         4281.16            575.         7.44549                 |
+-----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDPEA      -2.378869522       .33506420   -7.100   .0000     9.6576111
 INFLAT      -.2480965368   .19120869E-01  -12.975   .0000     6.8435319
 RGDINV       .2458873787   .25071319E-01    9.808   .0000     23.426389
 GGC     -.9339845527E-02   .25127287E-01    -.372   .7101     16.143889
 PTRADE   .7208001029E-02   .24858817E-02    2.900   .0037     63.987083
 LIFE        -4.944183290       3.7398291   -1.322   .1862     4.2999070
 RFERT       -.5403873250       .22930937   -2.357   .0184     2.0221085
 PURBAN   .1181958944E-01   .81328371E-02    1.453   .1461     70.876910
 Constant     43.03930508       15.638346    2.752   .0059
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
```

```
+--------------------------------------------------------------------+
| Least Squares with Group Dummy Variables                           |
| Ordinary    least squares regression    Weighting variable = none  |
| Dep. var. = RGDP     Mean=   2.923428403    , S.D.=   2.728642254  |
| Model size: Observations =     576, Parameters =  24, Deg.Fr.=   552 |
| Residuals:  Sum of squares= 2166.360550    , Std.Dev.=       1.98105 |
| Fit:        R-squared=  .493978, Adjusted R-squared =          .47289 |
| Model test: F[ 23,    552] =   23.43,    Prob value =         .00000 |
| Diagnostic: Log-L =  -1198.8211, Restricted(b=0) Log-L =   -1394.9994 |
|             LogAmemiyaPrCrt.=    1.408, Akaike Info. Crt.=      4.246 |
| Estd. Autocorrelation of e(i,t)     .185521                        |
+--------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDPEA      -3.451555806        1.0159552   -3.397   .0007     9.6576111
 INFLAT      -.2688656720   .20285087E-01  -13.254   .0000     6.8435319
 RGDINV       .2846775653   .34102117E-01    8.348   .0000     23.426389
 GGC         -.1898408097   .59262418E-01   -3.203   .0014     16.143889
 PTRADE    .8108955241E-01  .12134754E-01    6.682   .0000     63.987083
 LIFE        -13.87075805        8.7769884   -1.580   .1140     4.2999070
 RFERT       -1.138165551        .32736350   -3.477   .0005     2.0221085
 PURBAN    .4135041098E-01  .29753296E-01    1.390   .1646     70.876910
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

+----------------------------------------------------------------------+
|                Test Statistics for the Classical Model               |
|                                                                      |
|        Model              Log-Likelihood    Sum of Squares    R-squared |
| (1)  Constant term only     -1394.99935   .4281155915D+04      .0000000 |
| (2)  Group effects only     -1374.03257   .3980556887D+04      .0702145 |
| (3)  X - variables only     -1246.88103   .2559785135D+04      .4020808 |
| (4)  X and group effects    -1198.82111   .2166360550D+04      .4939777 |
|                                                                      |
|                              Hypothesis Tests                        |
|               Likelihood Ratio Test                 F Tests          |
|          Chi-squared   d.f.   Prob.           F     num. denom. Prob value |
| (2) vs (1)    41.934     15     .00023       2.819   15    560     .00029 |
| (3) vs (1)   296.237      8     .00000      47.661    8    567     .00000 |
| (4) vs (1)   392.356     23     .00000      23.429   23    552     .00000 |
| (4) vs (2)   350.423      8     .00000      57.783    8    552     .00000 |
| (4) vs (3)    96.120     15     .00000       6.683   15    552     .00000 |
+----------------------------------------------------------------------+
```

```
+----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables and Period Effects          |
| Ordinary    least squares regression    Weighting variable = none   |
| Dep. var. = RGDP     Mean=    2.923428403    , S.D.=    2.728642254  |
| Model size: Observations =      576, Parameters =  59, Deg.Fr.=   517 |
| Residuals:  Sum of squares= 1579.264130    , Std.Dev.=       1.74776 |
| Fit:        R-squared=  .631113, Adjusted R-squared =          .58973 |
| Model test: F[ 58,     517] =   15.25,     Prob value =         .00000 |
| Diagnostic: Log-L =  -1107.7873, Restricted(b=0) Log-L =   -1394.9994 |
|             LogAmemiyaPrCrt.=    1.214, Akaike Info. Crt.=      4.051 |
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDPEA       -6.180264289       1.1665175    -5.298    .0000     9.6576111
 INFLAT       -.1963587966    .25222341E-01   -7.785    .0000     6.8435319
 RGDINV        .2571240958    .32990621E-01    7.794    .0000     23.426389
 GGC          -.2038151656    .59428704E-01   -3.430    .0006     16.143889
 PTRADE     .7911324685E-01   .12210281E-01    6.479    .0000     63.987083
 LIFE         -22.27672987       9.7601218    -2.282    .0225     4.2999070
 RFERT        -.6449607403        .30891343   -2.088    .0368     2.0221085
 PURBAN     .5211116459E-01   .27329914E-01    1.907    .0566     70.876910
 Constant     149.5570293        37.519112     3.986    .0001
+------------------------------------------------------------------------+
|                 Test Statistics for the Classical Model                |
|                                                                        |
|        Model              Log-Likelihood    Sum of Squares    R-squared |
| (1)  Constant term only     -1394.99935    .4281155915D+04     .0000000 |
| (2)  Group effects only     -1374.03257    .3980556887D+04     .0702145 |
| (3)  X - variables only     -1246.88103    .2559785135D+04     .4020808 |
| (4)  X and group effects    -1198.82111    .2166360550D+04     .4939777 |
| (5)  X ind.&time effects    -1107.78730    .1579264130D+04     .6311127 |
|                                                                        |
|                            Hypothesis Tests                            |
|              Likelihood Ratio Test                F Tests              |
|           Chi-squared   d.f.  Prob.          F    num. denom. Prob value |
| (2) vs (1)    41.934     15     .00023     2.819    15    560      .00029 |
| (3) vs (1)   296.237      8     .00000    47.661     8    567      .00000 |
| (4) vs (1)   392.356     23     .00000    23.429    23    552      .00000 |
| (4) vs (2)   350.423      8     .00000    57.783     8    552      .00000 |
| (4) vs (3)    96.120     15     .00000     6.683    15    552      .00000 |
| (5) vs (4)   182.068     35     .00000     5.491    35    517      .00000 |
| (5) vs (3)   278.187     51     .00000     6.294    51    517      .00000 |
+------------------------------------------------------------------------+
--> Calc; list; Sumsq1=sumsqdev$
    Sumsq1   = 1579.264130
--> Calc; list; LL1=LogL$
    LL1      = -.11077873016150570D+04

? Joint Durbin-Wu-Hausman test (LM) for endogeneity
--> Calc; list; LM=Nreg*(Sumsq1-Sumsq0)/Sumsq1$
    LM       =  .85438153577626960D+02
--> Calc; list; Prob=1-Chi(LR, 3)$
    PROB     =  .00000000000000000D+00

? Joint Durbin-Wu-Hausman test (LR) for endogeneity
--> Calc; list; LR=2*(LL0-LL1)$
    LR       =  .92467153577626960D+02
--> Calc; list; Prob=1-Chi(LR, 3)$
    PROB     =  .00000000000000000D+00

--> Calc; list; ctb(0.99, 3)$
    Result   =  .11344866676609990D+02
```

```
?*******************************************
? DETAILED RESULTS OF M2.6 FOR ALTERNATIVE REGRESSIONS
?*******************************************

--> Namelist ; X21=LGDPea,INflat,RGDINV,GGC,PTrade,life,RFert,PUrban$
--> Namelist ; Y=RGDP $

--> Sample; all$
--> Create; LLGDPea=LGDPea[-1]
          ; LInflat=inflat[-1]
          ; LRGDINV=RGDINV[-1]
          ; LGGC=GGC[-1]
          ; Ltrade=ptrade[-1]
          ; Llife=life[-1]
          ; LRfert=Rfert[-1]
          ; Lurban=purban[-1] $

--> Namelist; IV=LGDPea, Ptrade, Life, Rfert, Linflat, LRGDINV, LGGC,
                 LTrade, Llife, LRfert, Lurban $
--> Reject  ; period=1$

--> Regress; Lhs= Inflat ;
            Rhs = IV;  Str=Ind; Period=period; Fixed;
            Panel; Keep=ZH1;
            Output=5$

+----------------------------------------------------------------------+
| OLS Without Group Dummy Variables                                    |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = INFLAT   Mean=   6.852998957    , S.D.=    5.399438779   |
| Model size: Observations =     575, Parameters =  12, Deg.Fr.=   563 |
| Residuals:  Sum of squares= 3818.827912    , Std.Dev.=       2.60442 |
| Fit:        R-squared=  .771797, Adjusted R-squared =         .76734 |
| Model test: F[ 11,    563] =  173.10,    Prob value =         .00000 |
| Diagnostic: Log-L =  -1360.2217, Restricted(b=0) Log-L =  -1785.0089 |
|             LogAmemiyaPrCrt.=    1.935, Akaike Info. Crt.=     4.773 |
| Panel Data Analysis of INFLAT      [ONE way]                         |
|           Unconditional ANOVA (No regressors)                        |
| Source      Variation        Deg. Free.     Mean Square              |
| Between       3637.56               15.         242.504              |
| Residual      13096.8              559.         23.4290              |
| Total         16734.4              574.         29.1539              |
+----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDPEA      -.9111364010       .41582977   -2.191   .0284    9.6582452
 PTRADE    .2299861130E-01  .11383965E-01    2.020   .0434    63.954887
 LIFE        -10.03031237       12.581166    -.797   .4253    4.2999760
 RFERT        .2836987170       .92349265     .307   .7587    2.0211209
 LINFLAT      .8110187008   .24255748E-01   33.436   .0000    6.8524598
 LRGDINV      .1730198035   .30992302E-01    5.583   .0000    23.417217
 LGGC      .5260546836E-01  .30721502E-01    1.712   .0868    16.155026
 LTRADE   -.1967132254E-01  .11353976E-01   -1.733   .0832    64.061843
 LLIFE        9.245091421       12.715153     .727   .4672    4.2997550
 LRFERT      -.1413166344       .91568440    -.154   .8774    2.0232078
 LURBAN    .8664624104E-02  .10024059E-01     .864   .3874    70.863826
 Constant     7.460316699       19.593956     .381   .7034
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
```

```
+----------------------------------------------------------------------------+
| Least Squares with Group Dummy Variables                                   |
| Ordinary    least squares regression    Weighting variable = none         |
| Dep. var. = INFLAT   Mean=   6.852998957    , S.D.=    5.399438779         |
| Model size: Observations =      575, Parameters =  27, Deg.Fr.=     548    |
| Residuals:  Sum of squares= 3376.263435    , Std.Dev.=        2.48215      |
| Fit:        R-squared=  .798244, Adjusted R-squared =          .78867      |
| Model test: F[ 26,     548] =   83.39,    Prob value =          .00000      |
| Diagnostic: Log-L =  -1324.8092, Restricted(b=0) Log-L =   -1785.0089      |
|             LogAmemiyaPrCrt.=    1.864, Akaike Info. Crt.=      4.702      |
| Estd. Autocorrelation of e(i,t)      .048457                               |
+----------------------------------------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LGDPEA	5.070180408	1.2926825	3.922	.0001	9.6582452
PTRADE	.6631503349E-01	.18302553E-01	3.623	.0003	63.954887
LIFE	-74.43986140	15.792279	-4.714	.0000	4.2999760
RFERT	.4530672527	.91726092	.494	.6214	2.0211209
LINFLAT	.7543353024	.25037644E-01	30.128	.0000	6.8524598
LRGDINV	.2604320411	.42235673E-01	6.166	.0000	23.417217
LGGC	-.3113430923E-01	.66366055E-01	-.469	.6390	16.155026
LTRADE	-.1121934904E-01	.11239155E-01	-.998	.3182	64.061843
LLIFE	34.23654302	13.085092	2.616	.0089	4.2997550
LRFERT	.2093796702	.88958813	.235	.8139	2.0232078
LURBAN	-.6066563302E-01	.30896456E-01	-1.964	.0496	70.863826

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

Test Statistics for the Classical Model

	Model	Log-Likelihood	Sum of Squares	R-squared
(1)	Constant term only	-1785.00886	.1673436106D+05	.0000000
(2)	Group effects only	-1714.54371	.1309680075D+05	.2173707
(3)	X - variables only	-1360.22168	.3818827912D+04	.7717972
(4)	X and group effects	-1324.80918	.3376263435D+04	.7982437

Hypothesis Tests

	Likelihood Ratio Test			F Tests			
	Chi-squared	d.f.	Prob.	F	num.	denom.	Prob value
(2) vs (1)	140.930	15	.00000	10.351	15	559	.00000
(3) vs (1)	849.574	11	.00000	173.100	11	563	.00000
(4) vs (1)	920.399	26	.00000	83.390	26	548	.00000
(4) vs (2)	779.469	11	.00000	143.431	11	548	.00000
(4) vs (3)	70.825	15	.00000	4.789	15	548	.00000

```
+--------------------------------------------------------------------+
| Least Squares with Group Dummy Variables and Period Effects        |
| Ordinary    least squares regression    Weighting variable = none  |
| Dep. var. = INFLAT   Mean=   6.852998957    , S.D.=   5.399438779  |
| Model size: Observations =      575, Parameters =  62, Deg.Fr.=    513 |
| Residuals:  Sum of squares= 2228.003322    , Std.Dev.=        2.08401 |
| Fit:        R-squared=  .866861, Adjusted R-squared =          .85103 |
| Model test: F[ 61,     513] =   54.76,    Prob value =         .00000 |
| Diagnostic: Log-L =  -1205.3058, Restricted(b=0) Log-L =   -1785.0089 |
|             LogAmemiyaPrCrt.=    1.571, Akaike Info. Crt.=      4.408 |
| Estd. Autocorrelation of e(i,t)     -.001190                      |
+--------------------------------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LGDPEA	1.310780860	1.4053377	.933	.3510	9.6582452
PTRADE	.4835885765E-02	.17683864E-01	.273	.7845	63.954887
LIFE	-19.88917789	19.325287	-1.029	.3034	4.2999760
RFERT	-.7349449401	.83002929	-.885	.3759	2.0211209
LINFLAT	.6760018848	.30211916E-01	22.375	.0000	6.8524598
LRGDINV	.1888736296	.39128210E-01	4.827	.0000	23.417217
LGGC	-.4014483802E-01	.63340719E-01	-.634	.5262	16.155026
LTRADE	.8247601519E-02	.11566818E-01	.713	.4758	64.061843
LLIFE	16.93262603	18.265653	.927	.3539	4.2997550
LRFERT	1.791946288	.81542855	2.198	.0280	2.0232078
LURBAN	-.6564084152E-01	.27273230E-01	-2.407	.0161	70.863826
Constant	.1772293782	45.768981	.004	.9969	

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

Test Statistics for the Classical Model

	Model	Log-Likelihood	Sum of Squares	R-squared
(1)	Constant term only	-1785.00886	.1673436106D+05	.0000000
(2)	Group effects only	-1714.54371	.1309680075D+05	.2173707
(3)	X - variables only	-1360.22168	.3818827912D+04	.7717972
(4)	X and group effects	-1324.80918	.3376263435D+04	.7982437
(5)	X ind.&time effects	-1205.30583	.2228003322D+04	.8668606

Hypothesis Tests

	Likelihood Ratio Test			F Tests			
	Chi-squared	d.f.	Prob.	F	num.	denom.	Prob value
(2) vs (1)	140.930	15	.00000	10.351	15	559	.00000
(3) vs (1)	849.574	11	.00000	173.100	11	563	.00000
(4) vs (1)	920.399	26	.00000	83.390	26	548	.00000
(4) vs (2)	779.469	11	.00000	143.431	11	548	.00000
(4) vs (3)	70.825	15	.00000	4.789	15	548	.00000
(5) vs (4)	239.007	35	.00000	7.554	35	513	.00000
(5) vs (3)	309.832	51	.00000	7.182	51	513	.00000

```
--> Regress; Lhs= RGDINV ;
            Rhs = IV;  Str=Ind; Period=period; Fixed;
            Panel;  Keep=ZH2;
            Output=5$
```

```
+-----------------------------------------------------------------------+
| OLS Without Group Dummy Variables                                     |
| Ordinary    least squares regression    Weighting variable = none     |
| Dep. var. = RGDINV   Mean=   23.43026087     , S.D.=    4.881575519   |
| Model size: Observations =      575, Parameters =  12, Deg.Fr.=   563 |
| Residuals:  Sum of squares= 2306.428964     , Std.Dev.=       2.02402 |
| Fit:        R-squared=  .831380, Adjusted R-squared =          .82809 |
| Model test: F[ 11,     563] =  252.35,     Prob value =        .00000 |
| Diagnostic: Log-L =  -1215.2518, Restricted(b=0) Log-L =   -1727.0333 |
|             LogAmemiyaPrCrt.=    1.431, Akaike Info. Crt.=      4.269 |
| Panel Data Analysis of RGDINV     [ONE way]                           |
|          Unconditional ANOVA (No regressors)                          |
| Source      Variation        Deg. Free.     Mean Square               |
| Between       6431.56              15.          428.771               |
| Residual      7246.73             559.          12.9637               |
| Total         13678.3             574.          23.8298               |
+-----------------------------------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LGDPEA	-.5884579682E-01	.32316221	-.182	.8555	9.6582452
PTRADE	-.4282229788E-02	.88470518E-02	-.484	.6284	63.954887
LIFE	-55.94422416	9.7774562	-5.722	.0000	4.2999760
RFERT	-1.398096327	.71769256	-1.948	.0514	2.0211209
LINFLAT	-.8464290204E-01	.18850361E-01	-4.490	.0000	6.8524598
LRGDINV	.8589405506	.24085676E-01	35.662	.0000	23.417217
LGGC	-.8942756245E-01	.23875223E-01	-3.746	.0002	16.155026
LTRADE	-.4441174395E-03	.88237455E-02	-.050	.9599	64.061843
LLIFE	51.99032397	9.8815841	5.261	.0000	4.2997550
LRFERT	1.215792396	.71162437	1.708	.0875	2.0232078
LURBAN	-.1293745686E-01	.77902004E-02	-1.661	.0968	70.863826
Constant	24.50753196	15.227448	1.609	.1075	

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

```
+----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables                             |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = RGDINV   Mean=   23.43026087    , S.D.=   4.881575519    |
| Model size: Observations =     575, Parameters =  27, Deg.Fr.=   548 |
| Residuals:  Sum of squares= 2090.521004     , Std.Dev.=       1.95316 |
| Fit:        R-squared=  .847165, Adjusted R-squared =          .83991 |
| Model test: F[ 26,    548] =  116.83,    Prob value =          .00000 |
| Diagnostic: Log-L =  -1186.9943, Restricted(b=0) Log-L =   -1727.0333 |
|             LogAmemiyaPrCrt.=    1.385, Akaike Info. Crt.=      4.223 |
| Estd. Autocorrelation of e(i,t)     .109596                          |
+----------------------------------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LGDPEA	-.7135715628	1.0171874	-.702	.4830	9.6582452
PTRADE	.4077827070E-01	.14401933E-01	2.831	.0046	63.954887
LIFE	-56.06831937	12.426646	-4.512	.0000	4.2999760
RFERT	-.9339705028	.72177527	-1.294	.1957	2.0211209
LINFLAT	-.5097478995E-01	.19701648E-01	-2.587	.0097	6.8524598
LRGDINV	.7234775610	.33234452E-01	21.769	.0000	23.417217
LGGC	-.2433119535	.52222193E-01	-4.659	.0000	16.155026
LTRADE	-.6011768660E-02	.88438787E-02	-.680	.4967	64.061843
LLIFE	48.04326173	10.296412	4.666	.0000	4.2997550
LRFERT	1.154928604	.70000007	1.650	.0990	2.0232078
LURBAN	.7749068047E-02	.24311837E-01	.319	.7499	70.863826

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

Test Statistics for the Classical Model

	Model	Log-Likelihood	Sum of Squares	R-squared
(1)	Constant term only	-1727.03333	.1367829346D+05	.0000000
(2)	Group effects only	-1544.39629	.7246733802D+04	.4702019
(3)	X - variables only	-1215.25179	.2306428964D+04	.8313804
(4)	X and group effects	-1186.99424	.2090521004D+04	.8471651

Hypothesis Tests

	Likelihood Ratio Test			F Tests			
	Chi-squared	d.f.	Prob.	F	num.	denom.	Prob value
(2) vs (1)	365.274	15	.00000	33.075	15	559	.00000
(3) vs (1)	1023.563	11	.00000	252.352	11	563	.00000
(4) vs (1)	1080.078	26	.00000	116.830	26	548	.00000
(4) vs (2)	714.804	11	.00000	122.875	11	548	.00000
(4) vs (3)	56.515	15	.00000	3.773	15	548	.00000

```
+----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables and Period Effects          |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = RGDINV   Mean=   23.43026087     , S.D.=    4.881575519  |
| Model size: Observations =     575, Parameters =  62, Deg.Fr.=   513 |
| Residuals:  Sum of squares= 1494.961031     , Std.Dev.=      1.70709 |
| Fit:        R-squared=  .890706, Adjusted R-squared =         .87771 |
| Model test: F[ 61,     513] =   68.54,     Prob value =       .00000 |
| Diagnostic: Log-L =  -1090.5917, Restricted(b=0) Log-L =  -1727.0333 |
|             LogAmemiyaPrCrt.=    1.172, Akaike Info. Crt.=     4.009 |
| Estd. Autocorrelation of e(i,t)     .124121                          |
+----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDPEA      -1.147551974       1.1511653     -.997   .3188     9.6582452
 PTRADE    .4660796823E-01  .14485523E-01     3.218   .0013     63.954887
 LIFE        27.62452592       15.830075     1.745   .0810     4.2999760
 RFERT       -2.428323214       .67990845    -3.572   .0004     2.0211209
 LINFLAT  -.7746489426E-01  .24747725E-01    -3.130   .0017     6.8524598
 LRGDINV      .7239477204   .32051400E-01    22.587   .0000     23.417217
 LGGC        -.2248644786   .51884783E-01    -4.334   .0000     16.155026
 LTRADE   -.1948901341E-01  .94748192E-02    -2.057   .0397     64.061843
 LLIFE       -14.60467736       14.962089     -.976   .3290     4.2997550
 LRFERT       2.988971638       .66794843     4.475   .0000     2.0232078
 LURBAN    .1658355446E-01  .22340536E-01      .742   .4579     70.863826
 Constant    -38.31084511       37.491107    -1.022   .3068
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)


+----------------------------------------------------------------------+
|                Test Statistics for the Classical Model               |
|                                                                      |
|        Model             Log-Likelihood    Sum of Squares   R-squared |
| (1)   Constant term only    -1727.03333   .1367829346D+05   .0000000 |
| (2)   Group effects only    -1544.39629   .7246733802D+04   .4702019 |
| (3)   X - variables only    -1215.25179   .2306428964D+04   .8313804 |
| (4)   X and group effects   -1186.99424   .2090521004D+04   .8471651 |
| (5)   X ind.&time effects   -1090.59170   .1494961031D+04   .8907056 |
|                                                                      |
|                           Hypothesis Tests                           |
|               Likelihood Ratio Test              F Tests             |
|          Chi-squared   d.f.  Prob.          F    num. denom. Prob value |
| (2) vs (1)    365.274     15     .00000    33.075   15   559     .00000 |
| (3) vs (1)   1023.563     11     .00000   252.352   11   563     .00000 |
| (4) vs (1)   1080.078     26     .00000   116.830   26   548     .00000 |
| (4) vs (2)    714.804     11     .00000   122.875   11   548     .00000 |
| (4) vs (3)     56.515     15     .00000     3.773   15   548     .00000 |
| (5) vs (4)    192.805     35     .00000     5.839   35   513     .00000 |
| (5) vs (3)    249.320     51     .00000     5.460   51   513     .00000 |
+----------------------------------------------------------------------+
```

```
--> Regress; Lhs= GGC ;
             Rhs = IV;  Str=Ind; Period=period; Fixed;
             Panel;  Keep=ZH3;
             Output=5$

+----------------------------------------------------------------------+
| OLS Without Group Dummy Variables                                    |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = GGC      Mean=   16.15057391     , S.D.=    4.705923562  |
| Model size: Observations =     575, Parameters =  12, Deg.Fr.=    563 |
| Residuals:  Sum of squares= 427.9156358    , Std.Dev.=          .87182 |
| Fit:        R-squared=  .966337, Adjusted R-squared =           .96568 |
| Model test: F[ 11,    563] = 1469.22,    Prob value =           .00000 |
| Diagnostic: Log-L =   -730.9495, Restricted(b=0) Log-L =   -1705.9619 |
|             LogAmemiyaPrCrt.=    -.254, Akaike Info. Crt.=      2.584 |
| Panel Data Analysis of GGC        [ONE way]                          |
|          Unconditional ANOVA (No regressors)                         |
| Source      Variation        Deg. Free.     Mean Square              |
| Between       9520.75              15.          634.717              |
| Residual      3190.89             559.          5.70822              |
| Total         12711.6             574.          22.1457              |
+----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDPEA       .4748210566       .13919691     3.411   .0006     9.6582452
 PTRADE   -.1912717097E-01  .38107250E-02    -5.019   .0000     63.954887
 LIFE         57.66322898       4.2114817    13.692   .0000     4.2999760
 RFERT        .8911971492       .30913450     2.883   .0039     2.0211209
 LINFLAT   .3225896269E-01  .81194892E-02     3.973   .0001     6.8524598
 LRGDINV   .2744920103E-01  .10374517E-01     2.646   .0081     23.417217
 LGGC         .9881645261   .10283868E-01    96.089   .0000     16.155026
 LTRADE    .1945835789E-01  .38006861E-02     5.120   .0000     64.061843
 LLIFE       -59.61014756       4.2563331   -14.005   .0000     4.2997550
 LRFERT      -.6380651252       .30652073    -2.082   .0374     2.0232078
 LURBAN    .2018840812E-02  .33555033E-02      .602   .5474     70.863826
 Constant     2.418900710       6.5589779      .369   .7123
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
```

```
+----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables                             |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = GGC      Mean=   16.15057391     , S.D.=   4.705923562   |
| Model size: Observations =     575, Parameters =  27, Deg.Fr.=    548 |
| Residuals:  Sum of squares= 342.5470393     , Std.Dev.=         .79062 |
| Fit:        R-squared=  .973052, Adjusted R-squared =           .97177 |
| Model test: F[ 26,    548] =  761.07,    Prob value =           .00000 |
| Diagnostic: Log-L =   -666.9759, Restricted(b=0) Log-L =   -1705.9619 |
|             LogAmemiyaPrCrt.=    -.424, Akaike Info. Crt.=      2.414 |
| Estd. Autocorrelation of e(i,t)     .189580                          |
+----------------------------------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LGDPEA	1.637123772	.41175020	3.976	.0001	9.6582452
PTRADE	-.2593821041E-01	.58297995E-02	-4.449	.0000	63.954887
LIFE	44.85947218	5.0302175	8.918	.0000	4.2999760
RFERT	.5275181409	.29216947	1.806	.0710	2.0211209
LINFLAT	.3930479902E-01	.79750866E-02	4.928	.0000	6.8524598
LRGDINV	.1624988312E-01	.13453069E-01	1.208	.2271	23.417217
LGGC	.8014110656	.21139171E-01	37.911	.0000	16.155026
LTRADE	.1379339870E-01	.35799389E-02	3.853	.0001	64.061843
LLIFE	-50.52191085	4.1679139	-12.122	.0000	4.2997550
LRFERT	-.6390327905	.28335503	-2.255	.0241	2.0232078
LURBAN	.1503198895E-01	.98412578E-02	1.527	.1267	70.863826

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

Test Statistics for the Classical Model

	Model	Log-Likelihood	Sum of Squares	R-squared
(1)	Constant term only	-1705.96190	.1271164131D+05	.0000000
(2)	Group effects only	-1308.57432	.3190892187D+04	.7489787
(3)	X - variables only	-730.94951	.4279156358D+03	.9663367
(4)	X and group effects	-666.97586	.3425470393D+03	.9730525

Hypothesis Tests

	Likelihood Ratio Test			F Tests			
	Chi-squared	d.f.	Prob.	F	num.	denom.	Prob value
(2) vs (1)	794.775	15	.00000	111.194	15	559	.00000
(3) vs (1)	1950.025	11	.00000	1469.223	11	563	.00000
(4) vs (1)	2077.972	26	.00000	761.071	26	548	.00000
(4) vs (2)	1283.197	11	.00000	414.248	11	548	.00000
(4) vs (3)	127.947	15	.00000	9.105	15	548	.00000

```
+-----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables and Period Effects           |
| Ordinary    least squares regression    Weighting variable = none     |
| Dep. var. = GGC      Mean=   16.15057391    , S.D.=   4.705923562     |
| Model size: Observations =      575, Parameters =  62, Deg.Fr.=    513 |
| Residuals:  Sum of squares= 289.6832476    , Std.Dev.=          .75146 |
| Fit:        R-squared=  .977211, Adjusted R-squared =          .97450 |
| Model test: F[ 61,    513] =  360.62,    Prob value =          .00000 |
| Diagnostic: Log-L =   -618.7849, Restricted(b=0) Log-L =   -1705.9619 |
|             LogAmemiyaPrCrt.=    -.469, Akaike Info. Crt.=      2.368 |
| Estd. Autocorrelation of e(i,t)     .227507                           |
+-----------------------------------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LGDPEA	1.183390098	.50673915	2.335	.0195	9.6582452
PTRADE	-.3826445228E-01	.63764789E-02	-6.001	.0000	63.954887
LIFE	16.62281499	6.9683463	2.385	.0171	4.2999760
RFERT	.9528748705	.29929344	3.184	.0015	2.0211209
LINFLAT	.2933881200E-01	.10893866E-01	2.693	.0071	6.8524598
LRGDINV	-.7138544593E-02	.14108920E-01	-.506	.6129	23.417217
LGGC	.7957460896	.22839509E-01	34.841	.0000	16.155026
LTRADE	.2559723968E-01	.41707839E-02	6.137	.0000	64.061843
LLIFE	-18.84305034	6.5862617	-2.861	.0042	4.2997550
LRFERT	-1.060479879	.29402867	-3.607	.0003	2.0232078
LURBAN	.5592584632E-02	.98342298E-02	.569	.5696	70.863826
Constant	2.005496048	16.503460	.122	.9033	

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

Test Statistics for the Classical Model

	Model	Log-Likelihood	Sum of Squares	R-squared
(1)	Constant term only	-1705.96190	.1271164131D+05	.0000000
(2)	Group effects only	-1308.57432	.3190892187D+04	.7489787
(3)	X - variables only	-730.94951	.4279156358D+03	.9663367
(4)	X and group effects	-666.97586	.3425470393D+03	.9730525
(5)	X ind.&time effects	-618.78484	.2896832476D+03	.9772112

Hypothesis Tests

	Likelihood Ratio Test			F Tests			
	Chi-squared	d.f.	Prob.	F	num.	denom.	Prob value
(2) vs (1)	794.775	15	.00000	111.194	15	559	.00000
(3) vs (1)	1950.025	11	.00000	1469.223	11	563	.00000
(4) vs (1)	2077.972	26	.00000	761.071	26	548	.00000
(4) vs (2)	1283.197	11	.00000	414.248	11	548	.00000
(4) vs (3)	127.947	15	.00000	9.105	15	548	.00000
(5) vs (4)	96.382	35	.00000	2.675	35	513	.00000
(5) vs (3)	224.329	51	.00000	4.800	51	513	.00000

```
--> Regress ;Lhs=Y;
            Rhs=INflat,RGDINV,GGC, LGDPea,PTrade,RFert,life,PUrban;
            Str=Ind;
            Period=period;
            Fixed;
            Inst= Zh1, Zh2, Zh3;
            Panel $
```

```
+-----------------------------------------------------------------------+
| OLS Without Group Dummy Variables                                     |
| Ordinary    least squares regression    Weighting variable = none     |
| Dep. var. = RGDP      Mean=   2.920488278    , S.D.=    2.730104755   |
| Model size: Observations =      575, Parameters =  12, Deg.Fr.=    563 |
| Residuals:  Sum of squares= 2489.799126     , Std.Dev.=        2.10295 |
| Fit:        R-squared=  .418039, Adjusted R-squared =           .40667 |
| Model test: F[ 11,     563] =   36.77,     Prob value =         .00000 |
| Diagnostic: Log-L =  -1237.2460, Restricted(b=0) Log-L =   -1392.8847 |
|             LogAmemiyaPrCrt.=    1.507, Akaike Info. Crt.=      4.345 |
| Panel Data Analysis of RGDP       [ONE way]                           |
|           Unconditional ANOVA (No regressors)                         |
| Source      Variation        Deg. Free.     Mean Square               |
| Between       301.508              15.         20.1005                |
| Residual      3976.79             559.         7.11411                |
| Total         4278.29             574.         7.45347                |
+-----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDPEA     -2.086337232       .34533482     -6.041   .0000     9.6582452
 INFLAT     -.2152736496    .21860178E-01    -9.848   .0000     6.8529990
 RGDINV      .2089663731    .28123350E-01     7.430   .0000     23.430261
 GGC      -.2521436506E-01  .26453394E-01     -.953   .3405     16.150574
 PTRADE    .6386473197E-02  .24987580E-02     2.556   .0106     63.954887
 LIFE       -5.297038777       3.7236038     -1.423   .1549     4.2999760
 RFERT      -.5016728939       .22810403     -2.199   .0279     2.0211209
 PURBAN    .8621447757E-02  .81863305E-02     1.053   .2923     70.838609
 ER1      -.9220854608E-01  .39386724E-01    -2.341   .0192  .39698912E-01
 ER2         .1243171223    .48136111E-01     2.583   .0098      .26061102
 ER3      -.6939420606E-01     .10592233      -.655   .5124    -.11684903
 Constant    42.79226209       15.557047      2.751   .0059
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
```

```
+----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables                             |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = RGDP     Mean=   2.920488278    , S.D.=    2.730104755   |
| Model size: Observations =      575, Parameters =  27, Deg.Fr.=   548 |
| Residuals:  Sum of squares= 2120.852810    , Std.Dev.=       1.96727 |
| Fit:        R-squared=  .504276, Adjusted R-squared =         .48076 |
| Model test: F[ 26,    548] =   21.44,    Prob value =         .00000 |
| Diagnostic: Log-L =  -1191.1357, Restricted(b=0) Log-L =  -1392.8847 |
|             LogAmemiyaPrCrt.=    1.399, Akaike Info. Crt.=     4.237 |
| Estd. Autocorrelation of e(i,t)     .187611                          |
+----------------------------------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LGDPEA	-3.104752776	1.0408770	-2.983	.0029	9.6582452
INFLAT	-.2249413031	.24957269E-01	-9.013	.0000	6.8529990
RGDINV	.2073433508	.44949175E-01	4.613	.0000	23.430261
GGC	-.2492290140	.70592825E-01	-3.531	.0004	16.150574
PTRADE	.8174306115E-01	.12220841E-01	6.689	.0000	63.954887
LIFE	-16.63345802	8.9400827	-1.861	.0628	4.2999760
RFERT	-1.029275050	.32717391	-3.146	.0017	2.0211209
PURBAN	.5039677328E-01	.29821547E-01	1.690	.0910	70.838609
ER1	-.1053828383	.39659932E-01	-2.657	.0079	.39698912E-01
ER2	.1320802972	.53301355E-01	2.478	.0132	.26061102
ER3	.6231260836E-01	.11600201	.537	.5912	-.11684903

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

```
+----------------------------------------------------------------------+
|                Test Statistics for the Classical Model               |
|                                                                      |
|        Model              Log-Likelihood    Sum of Squares    R-squared |
| (1)  Constant term only     -1392.88471   .4278292912D+04     .0000000 |
| (2)  Group effects only     -1371.87411   .3976785128D+04     .0704739 |
| (3)  X - variables only     -1237.24600   .2489799126D+04     .4180391 |
| (4)  X and group effects    -1191.13567   .2120852810D+04     .5042759 |
|                                                                      |
|                            Hypothesis Tests                          |
|              Likelihood Ratio Test                 F Tests           |
|           Chi-squared   d.f.  Prob.          F     num. denom. Prob value |
| (2) vs (1)     42.021     15     .00022     2.825    15    559     .00029 |
| (3) vs (1)    311.277     11     .00000    36.765    11    563     .00000 |
| (4) vs (1)    403.498     26     .00000    21.441    26    548     .00000 |
| (4) vs (2)    361.477     11     .00000    43.595    11    548     .00000 |
| (4) vs (3)     92.221     15     .00000     6.355    15    548     .00000 |
+----------------------------------------------------------------------+
```

```
+--------------------------------------------------------------------+
| Least Squares with Group Dummy Variables and Period Effects        |
| Ordinary    least squares regression    Weighting variable = none  |
| Dep. var. = RGDP     Mean=   2.923428403    , S.D.=   2.728642254  |
| Model size: Observations =     576, Parameters =  59, Deg.Fr.=  517 |
| Residuals:  Sum of squares= 1883.149631    , Std.Dev.=     1.90852 |
| Fit:        R-squared=  .559231, Adjusted R-squared =       .50978 |
| Model test: F[ 58,    517] =   11.35,    Prob value =       .00000 |
| Diagnostic: Log-L =  -1158.4715, Restricted(b=0) Log-L =  -1394.9994 |
|             LogAmemiyaPrCrt.=    1.390, Akaike Info. Crt.=    4.229 |
| Estd. Autocorrelation of e(i,t)     .130817                        |
+--------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 INFLAT      -.1936969916   .38062218E-01    -5.114   .0000    6.8520330
 RGDINV    .5354065030E-01  .50527051E-01    1.068   .3077    23.428472
 GGC         -.1587491295   .71312518E-01    -2.225   .0233    16.136817
 LGDPEA      -4.955264286      1.2823806    -3.860   .0001    9.6576111
 PTRADE    .9031253643E-01  .13391076E-01    6.746   .0000    63.987083
 RFERT       -.2942941275      .34136695     -.859   .4050    2.0221085
 LIFE        -15.10165201      10.755495    -1.467   .1443    4.2999070
 PURBAN    .5514587235E-01  .30918968E-01    1.772   .0745    70.876910
 Constant    112.2517762      41.502222     2.702   .0071
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

+---------------------------------------------------------------------+
|                 Test Statistics for the Classical Model             |
|                                                                     |
|        Model              Log-Likelihood    Sum of Squares   R-squared |
| (1)  Constant term only     -1394.99935   .4281155915D+04    .0000000 |
| (2)  Group effects only     -1374.03257   .3980556887D+04    .0702145 |
| (3)  X - variables only     -1253.90233   .2622958386D+04    .3873247 |
| (4)  X and group effects    -1219.29270   .2325954553D+04    .4566994 |
| (5)  X ind.&time effects    -1158.47147   .1883149631D+04    .5601306 |
+---------------------------------------------------------------------+

--> Calc; list; LL0=LogL$
    LL0      = -.11584714749099370D+04

--> Calc; list; SBI=(-2/Nreg)*(LogL-(Kreg+1)*(0.5)*log(Nreg))$
    SBI      =  .46755300378488400D+01

--> Calc; list; AKI=(-2/Nreg)*(LogL-Kreg-1)$
    AKI      =  .42293315101039480D+01
```

```
?******************************************************************
? ADDITIONAL RESULTS OF M2.1 WITH DYNAMIC PANEL DATA ESTIMATION
? STATA 8.0 IS USED
?******************************************************************
? Descriptions of variables
? lgdp      - log per capita GDP
? Inflat    - inflation rate
? rgdinv    - investment ratio in GDP
? ggc       - general government consumption ratio
? ptrade    - openness (total trade/GDP)
? life      - log life expectancy
? rfert     - fertility rate
? purban    - urbanisation
?************************************************************
```

. do "H:\Chapter4\chapter421.do"
. insheet using "H:\Cahpter4\chapter421.csv" (52 vars, 592 obs)
. tsset ind year, yearly
panel variable: ind, 1 to 16
time variable: year, 1961 to 1997

.
. set matsize 800
. xtabond lgdp inflat rgdinv ggc ptrade life rfert purban, lags(1) artests(2)

Arellano-Bond dynamic panel-data estimation — Number of obs = 560
Group variable (i): ind — Number of groups = 16
Wald chi2(8) = 13012.60
Time variable (t): year — Obs per group: min = 35
avg = 35
max = 35

One-step results

D.lgdp	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lgdp (LD)	.9392921	.01194	78.67	0.000	.9158902	.962694
Inflat (D1)	-.0023072	.000202	-11.42	0.000	-.002703	-.0019113
rgdinv (D1)	.0031515	.0003232	9.75	0.000	.002518	.0037849
ggc (D1)	-.0040652	.0006505	-6.25	0.000	-.0053402	-.0027902
ptrade (D1)	.000759	.0001235	6.15	0.000	.000517	.001001
life (D1)	-.2276491	.1008719	-2.26	0.024	-.4253545	-.0299438
rfert (D1)	-.0154913	.0032473	-4.77	0.000	-.0218559	-.0091268
purban (D1)	.0007144	.0003357	2.13	0.033	.0000564	.0013724
-cons	.0012767	.0003608	3.54	0.000	.0005696	.0019838

Sargan test of over-identifying restrictions:
chi2(629) = 564.32 Prob > chi2 = 0.9693
Arellano-Bond test that average autocovariance in residuals of order 1 is 0:
H0: no autocorrelation z = -7.13 Pr > z = 0.0000
Arellano-Bond test that average autocovariance in residuals of order 2 is 0:
H0: no autocorrelation z = -4.44 Pr > z = 0.0000

. xtabond rgdp inflat rgdinv ggc rfert ptrade purban life, lags(1) twostep

Arellano-Bond dynamic panel-data estimation   Number of obs = 560
Group variable (i): ind   Number of groups = 16

Wald chi2(8) = 4818.21

Time variable (t): year   Obs per group: min = 35
avg = 35
max = 35

Two-step results

D.lgdp	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lgdp (LD)	.6313737	.1845817	3.42	0.001	.2696002	.9931471
Inflat (D1)	-.0012952	.00059	-2.20	0.028	-.0024517	-.0001388
rgdinv (D1)	.0036735	.0010536	3.49	0.000	.0016086	.0057385
Ggc (D1)	-.0066695	.0048089	-1.39	0.165	-.0160947	.0027558
ptrade (D1)	-.0039601	.0257431	-0.15	0.878	-.0544156	.0464955
life (D1)	.0004587	.0003304	1.39	0.165	-.0001888	.0011062
rfert (D1)	.0123187	.0110413	1.12	0.265	-.0093218	.0339593
purban (D1)	-2.812879	2.606009	-1.08	0.280	-7.920563	2.294805
-cons	.0145847	.0101199	1.44	0.150	-.0052499	.0344193

Warning: Arellano and Bond recommend using one-step results for inference on coefficients

Sargan test of over-identifying restrictions:
chi2(629) = 10.52 Prob > chi2 = 1.0000

Arellano-Bond test that average autocovariance in residuals of order 1 is 0:
H0: no autocorrelation z = -1.33 Pr > z = 0.1830
Arellano-Bond test that average autocovariance in residuals of order 2 is 0:
H0: no autocorrelation z = -0.94 Pr > z = 0.3447

APPENDIX N

SOME DETAILED RESULTS OF REGRESSIONS AND TESTS FOR CHAPTER 5

This appendix contains two example of more detailed results of regressions and tests for chapter five. The first example is the results of M3.1 of table 5.3. It contains alternative regressions for a number of test statistics including F-test for fixed effects and Hausman's test for fixed against random effects. The second is the results of M3.2 of table 5.3. Appendix A has presented a detailed presentation of the methodologies employed in this appendix.

```
? load file chapter501.xls which contains the data
--> RESET
--> Read
    ; File=H:\chapter5\chapter501.xls
    ; Format=xls
    ; Names$
?************************************************************
? Descriptions of variables
? GDP       - Per capita growth rate of GDP
? LGDP      - Log of GDP per capita lagged one period
? INV       - Investment share in GDP
? LPCI      - Log of annual inflation rate
? PRLIB     - EBRD index of price liberalisation
? PRC       - Change rate of above index
? FTLIB     - EBRD index of trade liberalisation
? FTC       - Change rate of above index
? SCPRIV    - EBRD index of small-scale privatisation
? SCC       - Change rate of above index
? LSPRIV    - EBRD index of large-scale privatisation
? LSC       - Change rate of above index
? ENTRF     - EBRD index of enterprise reform
? ENTC      - Change rate of above index
? COMP      - EBRD index of competition policy
? COMC      - Change rate of above index
? BANKSRF   - EBRD index of banking sector reform
? BANC      - Change rate of above index
? NBANKSRF  - EBRD index of reform of non-banking financial institutions
? NBANC     - Change rate of above index
??????????????????????????????????????????????????????????????????????????
```

```
?*******************************************
? DETAILED RESULTS OF M3.1 FOR ALTERNATIVE REGRESSIONS
?*******************************************
```

```
--> Namelist ; X31=PrLib, PrC, FTLib, FTC,
                 SCPriv, SCC, LSPriv, LSC,
                 EntRF, EntC, ComP, ComC,
                 BankSRF, BanC, NBankSRF, NbanC$
--> Regress ;
               Lhs=GDP;
               Rhs=LGDP, Inv, LPCI, X31;
               Str=Ind;
               Period=period;
               Panel $
```

```
+-----------------------------------------------------------------------+
| OLS Without Group Dummy Variables                                     |
| Ordinary    least squares regression    Weighting variable = none     |
| Dep. var. = GDP      Mean=  -1.210666667    , S.D.=    9.746467858    |
| Model size: Observations =     225, Parameters =  20, Deg.Fr.=    205 |
| Residuals:  Sum of squares= 8668.439491    , Std.Dev.=        6.50270 |
| Fit:        R-squared=  .592621, Adjusted R-squared =          .55486 |
| Model test: F[ 19,     205] =   15.70,     Prob value =         .00000 |
| Diagnostic: Log-L =    -730.0373, Restricted(b=0) Log-L =    -831.0637 |
|             LogAmemiyaPrCrt.=    3.830, Akaike Info. Crt.=      6.667 |
| Panel Data Analysis of GDP         [ONE way]                          |
|           Unconditional ANOVA (No regressors)                         |
| Source      Variation         Deg. Free.     Mean Square              |
| Between       3292.36               24.         137.182              |
| Residual      17986.2              200.         89.9311              |
| Total         21278.6              224.         94.9936              |
+-----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |t-ratio |P[|T|>t] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDP       -1.677656993     .86064125    -1.949   .0526      7.4156089
 INV       .6431684034E-01 .62535318E-01   1.028   .3049      23.062716
 LPCI       -3.933754850     .89303296    -4.405   .0000      1.6304444
 PRLIB       1.289789442     1.3912970      .927   .3550      2.7804444
 PRC        -10.43257817     1.8727363    -5.571   .0000  .83155556E-01
 FTLIB       .5874976738     .90879232      .646   .5187      3.1857778
 FTC         .4818465314     1.5581099      .309   .7574      .13751111
 SCPRIV      2.282854198     1.0263710     2.224   .0272      3.2057778
 SCC        -5.104019432     1.8006803    -2.834   .0050      .13862222
 LSPRIV     -1.782276301     .97695722    -1.824   .0696      2.4586667
 LSC         2.396825529     1.7451556     1.373   .1711      .14551111
 ENTRF       2.291947668     1.7695918     1.295   .1967      2.0115556
 ENTC       -3.766148932     2.1747299    -1.732   .0848      .10457778
 COMP       -.9076744120     1.2564357     -.722   .4709      1.9071111
 COMC       -1.057537457     1.8596934     -.569   .5702  .90133333E-01
 BANKSRF    -2.688970443     1.6862364    -1.595   .1123      2.1586667
 BANC        1.225044871     2.2784338      .538   .5914      .11262222
 NBANKSRF    2.244842538     1.3915572     1.613   .1082      1.8244444
 NBANC      -.4399656011     1.8531922     -.237   .8126  .97688889E-01
 Constant    8.150381287     6.0094010     1.356   .1765
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
```

```
+----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables                             |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = GDP      Mean=  -1.210666667    , S.D.=    9.746467858   |
| Model size: Observations =     225, Parameters =  44, Deg.Fr.=   181 |
| Residuals:  Sum of squares= 4795.151042    , Std.Dev.=       5.14709 |
| Fit:        R-squared=  .774649, Adjusted R-squared =         .72111 |
| Model test: F[ 43,    181] =   14.47,    Prob value =         .00000 |
| Diagnostic: Log-L =   -663.4279, Restricted(b=0) Log-L =    -831.0637 |
|             LogAmemiyaPrCrt.=    3.455, Akaike Info. Crt.=      6.288 |
| Estd. Autocorrelation of e(i,t)     .230443                          |
+----------------------------------------------------------------------+
```

Variable	Coefficient	Standard Error	t-ratio	P[|T|>t]	Mean of X
LGDP	-27.28621837	3.4104809	-8.001	.0000	7.4156089
INV	.2768533834	.69056032E-01	4.009	.0001	23.062716
LPCI	-3.625218590	.82776551	-4.380	.0000	1.6304444
PRLIB	-3.551919639	1.4351079	-2.475	.0141	2.7804444
PRC	-4.734682486	1.7446502	-2.714	.0072	.83155556E-01
FTLIB	1.503899493	1.0637954	1.414	.1590	3.1857778
FTC	-1.364630401	1.3608246	-1.003	.3171	.13751111
SCPRIV	.8871143843E-01	1.2790496	.069	.9448	3.2057778
SCC	-2.552756455	1.5936838	-1.602	.1107	.13862222
LSPRIV	-.2699925652	1.1501167	-.235	.8146	2.4586667
LSC	1.639389897	1.4478498	1.132	.2588	.14551111
ENTRF	.9926459366E-01	1.9053461	.052	.9585	2.0115556
ENTC	-2.593497042	1.8597792	-1.395	.1647	.10457778
COMP	-.5181136279E-01	1.6320670	-.032	.9747	1.9071111
COMC	-.6756023308	1.6203125	-.417	.6771	.90133333E-01
BANKSRF	.6167635856	1.5862198	.389	.6978	2.1586667
BANC	-.7618613126	1.9015357	-.401	.6891	.11262222
NBANKSRF	.6420236915	1.3517821	.475	.6353	1.8244444
NBANC	.1541003602E-01	1.5390914	.010	.9920	.97688889E-01

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

Test Statistics for the Classical Model

Model	Log-Likelihood	Sum of Squares	R-squared
(1) Constant term only	-831.06367	.2127857440D+05	.0000000
(2) Group effects only	-812.15299	.1798621621D+05	.1547264
(3) X - variables only	-730.03733	.8668439491D+04	.5926212
(4) X and group effects	-663.42793	.4795151042D+04	.7746489

Hypothesis Tests

	Likelihood Ratio Test			F Tests			
	Chi-squared	d.f.	Prob.	F	num.	denom.	Prob value
(2) vs (1)	37.821	24	.03616	1.525	24	200	.06237
(3) vs (1)	202.053	19	.00000	15.696	19	205	.00000
(4) vs (1)	335.271	43	.00000	14.470	43	181	.00000
(4) vs (2)	297.450	19	.00000	26.206	19	181	.00000
(4) vs (3)	133.219	24	.00000	6.092	24	181	.00000

```
+--------------------------------------------------+
| Random Effects Model: v(i,t) = e(i,t) + u(i)     |
| Estimates:  Var[e]              =   .264925D+02  |
|             Var[u]              =   .157925D+02  |
|             Corr[v(i,t),v(i,s)] =   .373478      |
| Lagrange Multiplier Test vs. Model (3) =   10.63 |
| ( 1 df, prob value =  .001111)                   |
| (High values of LM favor FEM/REM over CR model.) |
| Fixed vs. Random Effects (Hausman)     =   67.24 |
| (19 df, prob value =  .000000)                   |
| (High (low) values of H favor FEM (REM).)        |
| Reestimated using GLS coefficients:              |
| Estimates:  Var[e]              =   .333718D+02  |
|             Var[u]              =   .832621D+02  |
|             Sum of Squares          .101217D+05  |
+--------------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LGDP	-4.697215388	1.1736952	-4.002	.0001	7.4156089
INV	.1653275219	.62315863E-01	2.653	.0080	23.062716
LPCI	-3.127912952	.78321498	-3.994	.0001	1.6304444
PRLIB	.7042834919	1.2585065	.560	.5757	2.7804444
PRC	-9.442420119	1.5874543	-5.948	.0000	.83155556E-01
FTLIB	1.894979279	.94723998	2.001	.0454	3.1857778
FTC	.3089859142	1.3081767	.236	.8133	.13751111
SCPRIV	2.437456952	1.1003624	2.215	.0268	3.2057778
SCC	-4.123027627	1.5323784	-2.691	.0071	.13862222
LSPRIV	-1.679472814	1.0338013	-1.625	.1043	2.4586667
LSC	1.967623438	1.4283727	1.378	.1683	.14551111
ENTRF	2.836203208	1.7245353	1.645	.1000	2.0115556
ENTC	-4.189058356	1.8055065	-2.320	.0203	.10457778
COMP	-1.292838266	1.3883021	-.931	.3517	1.9071111
COMC	-.7808431189	1.5609867	-.500	.6169	.90133333E-01
BANKSRF	-.8410557543	1.5128153	-.556	.5782	2.1586667
BANC	.4078110284	1.8697282	.218	.8273	.11262222
NBANKSRF	-.6892104230E-01	1.2776506	-.054	.9570	1.8244444
NBANC	-.5680843365E-01	1.5199311	-.037	.9702	.97688889E-01
Constant	23.41563646	8.7813353	2.667	.0077	

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

```
+----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables and Period Effects          |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = GDP      Mean=  -1.210666667    , S.D.=    9.746467858   |
| Model size: Observations =     225, Parameters =  53, Deg.Fr.=    172 |
| Residuals:  Sum of squares= 4078.387588    , Std.Dev.=        4.86945 |
| Fit:        R-squared=  .808334, Adjusted R-squared =          .75039 |
| Model test: F[ 52,    172] =   13.95,    Prob value =          .00000 |
| Diagnostic: Log-L =   -645.2138, Restricted(b=0) Log-L =    -831.0637 |
|             LogAmemiyaPrCrt.=    3.377, Akaike Info. Crt.=      6.206 |
| Estd. Autocorrelation of e(i,t)     .139430                          |
+----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |t-ratio |P[|T|>t] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDP        -30.12449021       3.5761756   -8.424   .0000     7.4156089
 INV          .3288697841    .67169077E-01   4.896   .0000     23.062716
 LPCI        -2.449136074       .91203647   -2.685   .0078     1.6304444
 PRLIB       -3.410746219       1.4744610   -2.313   .0217     2.7804444
 PRC         -3.440548025       1.7429316   -1.974   .0497  .83155556E-01
 FTLIB        2.192134517       1.0566782    2.075   .0393     3.1857778
 FTC         -1.469106218       1.3369313   -1.099   .2731      .13751111
 SCPRIV      -.4424890989       1.2678450    -.349   .7274     3.2057778
 SCC         -1.717401799       1.5773061   -1.089   .2775      .13862222
 LSPRIV      -1.356018709       1.1633481   -1.166   .2451     2.4586667
 LSC          1.996577116       1.4214608    1.405   .1617      .14551111
 ENTRF     .5687928502E-01      1.9094965     .030   .9763     2.0115556
 ENTC        -2.491279077       1.7965511   -1.387   .1670      .10457778
 COMP        -1.755735154       1.6447641   -1.067   .2870     1.9071111
 COMC         .4220755210       1.6308783     .259   .7960  .90133333E-01
 BANKSRF     -.1123236758       1.5290675    -.073   .9415     2.1586667
 BANC        -1.139298507       1.8509346    -.616   .5389      .11262222
 NBANKSRF    -.5766206032       1.3990548    -.412   .6807     1.8244444
 NBANC        1.432053207       1.5829174     .905   .3667  .97688889E-01
 Constant     231.0165942       27.289574    8.465   .0000
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
```

```
+------------------------------------------------------------------------+
|                Test Statistics for the Classical Model                 |
|                                                                        |
|        Model              Log-Likelihood    Sum of Squares    R-squared |
| (1)  Constant term only      -831.06367   .2127857440D+05     .0000000  |
| (2)  Group effects only      -812.15299   .1798621621D+05     .1547264  |
| (3)  X - variables only      -730.03733   .8668439491D+04     .5926212  |
| (4)  X and group effects     -663.42793   .4795151042D+04     .7746489  |
| (5)  X ind.&time effects     -645.21379   .4078387588D+04     .8083336  |
|                                                                        |
|                             Hypothesis Tests                           |
|                Likelihood Ratio Test               F Tests             |
|           Chi-squared   d.f.  Prob.          F    num. denom.  Prob value |
| (2) vs (1)     37.821     24     .03616     1.525   24   200      .06237 |
| (3) vs (1)    202.053     19     .00000    15.696   19   205      .00000 |
| (4) vs (1)    335.271     43     .00000    14.470   43   181      .00000 |
| (4) vs (2)    297.450     19     .00000    26.206   19   181      .00000 |
| (4) vs (3)    133.219     24     .00000     6.092   24   181      .00000 |
| (5) vs (4)     36.428      9     .00003     3.359    9   172      .00082 |
| (5) vs (3)    169.647     34     .00000     5.693   34   172      .00000 |
+------------------------------------------------------------------------+
```

```
+--------------------------------------------------------+
| Random Effects Model: v(i,t) = e(i,t) + u(i) + w(t)    |
| Estimates:  Var[e]              =   .237116D+02        |
|             Var[u]              =   .665674D+03        |
|             Corr[v(i,t),v(i,s)] =   .965605            |
|             Var[w]              =   .499921D+02        |
|             Corr[v(i,t),v(j,t)] =   .678285            |
| Lagrange Multiplier Test vs. Model (3) =   10.65       |
| ( 2 df, prob value =  .004863)                         |
| (High values of LM favor FEM/REM over CR model.)       |
| Fixed vs. Random Effects (Hausman)     =   47.39       |
| (19 df, prob value =  .000314)                         |
| (High (low) values of H favor FEM (REM).)              |
| Reestimated using GLS coefficients:                    |
| Estimates:  Var[e]              =   .311357D+02        |
|             Var[u]              =   .500935D+03        |
|             Var[w]              =   .163866D+03        |
|             Sum of Squares          .279950D+05        |
+--------------------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LGDP	-12.16004751	2.2180585	-5.482	.0000	7.4156089
INV	.2298298663	.65313094E-01	3.519	.0004	23.062716
LPCI	-2.817696835	.90043728	-3.129	.0018	1.6304444
PRLIB	-1.528379738	1.4319009	-1.067	.2858	2.7804444
PRC	-7.377843708	1.6422398	-4.493	.0000	.83155556E-01
FTLIB	3.016695190	1.0331054	2.920	.0035	3.1857778
FTC	-.3213649681	1.3236585	-.243	.8082	.13751111
SCPRIV	1.117989366	1.2353816	.905	.3655	3.2057778
SCC	-3.483582535	1.5506280	-2.247	.0247	.13862222
LSPRIV	-1.859130257	1.1274813	-1.649	.0992	2.4586667
LSC	1.463254661	1.4151919	1.034	.3012	.14551111
ENTRF	1.868532516	1.8756457	.996	.3191	2.0115556
ENTC	-3.596425042	1.7862943	-2.013	.0441	.10457778
COMP	-2.384637441	1.6083575	-1.483	.1382	1.9071111
COMC	-.3494619005	1.6144427	-.216	.8286	.90133333E-01
BANKSRF	.2887849583	1.5229109	.190	.8496	2.1586667
BANC	-.7470499822	1.8478375	-.404	.6860	.11262222
NBANKSRF	-1.409868560	1.3500298	-1.044	.2963	1.8244444
NBANC	.5460968635	1.5642054	.349	.7270	.97688889E-01
Constant	87.24652822	17.598754	4.958	.0000	

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

```
?*******************************************
? DETAILED RESULTS OF M3.2 FOR ALTERNATIVE REGRESSIONS
?*******************************************


--> Namelist ; X32=PrLib, PrC, FTLib, FTC,
                 LSPriv, LSC,
                 EntC $
--> Regress ;
               Lhs=GDP;
               Rhs=LGDP, Inv, LPCI, X32;
               Str=Ind;
               Period=period;
               Panel $
```

```
+------------------------------------------------------------------------+
| OLS Without Group Dummy Variables                                      |
| Ordinary    least squares regression    Weighting variable = none      |
| Dep. var. = GDP      Mean=  -1.210666667    , S.D.=    9.746467858     |
| Model size: Observations =     225, Parameters =  11, Deg.Fr.=    214  |
| Residuals:  Sum of squares= 9546.621932    , Std.Dev.=        6.67910  |
| Fit:        R-squared=  .551350, Adjusted R-squared =          .53039  |
| Model test: F[ 10,    214] =   26.30,    Prob value =          .00000  |
| Diagnostic: Log-L =   -740.8934, Restricted(b=0) Log-L =    -831.0637  |
|             LogAmemiyaPrCrt.=    3.846, Akaike Info. Crt.=      6.683  |
| Panel Data Analysis of GDP        [ONE way]                            |
|           Unconditional ANOVA (No regressors)                          |
| Source      Variation        Deg. Free.     Mean Square               |
| Between       3292.36              24.         137.182                 |
| Residual      17986.2             200.         89.9311                 |
| Total         21278.6             224.         94.9936                 |
+------------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |t-ratio |P[|T|>t] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDP       -1.016386532       .68237923     -1.489   .1378     7.4156089
 INV      .4160349510E-01  .59093260E-01       .704   .4822     23.062716
 LPCI       -4.671542956       .79749119     -5.858   .0000     1.6304444
 PRLIB       2.165992004       1.3054250      1.659   .0985     2.7804444
 PRC        -11.42671842       1.8576006     -6.151   .0000  .83155556E-01
 FTLIB       .7333516200       .82036479       .894   .3724     3.1857778
 FTC      -.4674273824E-01     1.5196759     -.031   .9755     .13751111
 LSPRIV     -.2823164737       .80182299     -.352   .7251     2.4586667
 LSC         .1527304125       1.6266215       .094   .9253     .14551111
 ENTC       -3.583456296       1.7155885     -2.089   .0379     .10457778
 Constant    6.628215086       5.4238125      1.222   .2230
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
```

```
+----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables                             |
| Ordinary    least squares regression    Weighting variable = none    |
| Dep. var. = GDP      Mean=  -1.210666667    , S.D.=    9.746467858   |
| Model size: Observations =      225, Parameters =  35, Deg.Fr.=   190 |
| Residuals:  Sum of squares= 4911.267184    , Std.Dev.=       5.08417 |
| Fit:        R-squared=  .769192, Adjusted R-squared =          .72789 |
| Model test: F[ 34,    190] =   18.62,    Prob value =          .00000 |
| Diagnostic: Log-L =    -666.1197, Restricted(b=0) Log-L =   -831.0637 |
|             LogAmemiyaPrCrt.=    3.397, Akaike Info. Crt.=     6.232 |
| Estd. Autocorrelation of e(i,t)     .220724                          |
+----------------------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |t-ratio |P[|T|>t] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDP       -27.28314425       3.0465106   -8.956   .0000     7.4156089
 INV         .2800777611   .64895990E-01    4.316   .0000     23.062716
 LPCI       -3.876684893       .73044898   -5.307   .0000     1.6304444
 PRLIB      -3.692180067       1.3185266   -2.800   .0056     2.7804444
 PRC        -4.544473960       1.6624759   -2.734   .0068  .83155556E-01
 FTLIB       1.872814025       .96878062    1.933   .0545     3.1857778
 FTC        -1.986699673       1.2348254   -1.609   .1091     .13751111
 LSPRIV      .4712568082       .89072102     .529   .5973     2.4586667
 LSC         .8075340221       1.2779578     .632   .5281     .14551111
 ENTC       -2.895946070       1.3234220   -2.188   .0297     .10457778
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
```

```
+-----------------------------------------------------------------------+
|                Test Statistics for the Classical Model                |
|                                                                       |
|       Model              Log-Likelihood    Sum of Squares    R-squared |
| (1)  Constant term only     -831.06367   .2127857440D+05    .0000000 |
| (2)  Group effects only     -812.15299   .1798621621D+05    .1547264 |
| (3)  X - variables only     -740.89342   .9546621932D+04    .5513505 |
| (4)  X and group effects    -666.11969   .4911267184D+04    .7691919 |
|                                                                       |
|                            Hypothesis Tests                           |
|                Likelihood Ratio Test                F Tests           |
|           Chi-squared   d.f.  Prob.          F    num. denom. Prob value |
| (2) vs (1)    37.821     24     .03616     1.525   24   200     .06237 |
| (3) vs (1)   180.340     10     .00000    26.299   10   214     .00000 |
| (4) vs (1)   329.888     34     .00000    18.623   34   190     .00000 |
| (4) vs (2)   292.067     10     .00000    50.582   10   190     .00000 |
| (4) vs (3)   149.547     24     .00000     7.472   24   190     .00000 |
+-----------------------------------------------------------------------+
```

```
+--------------------------------------------------+
| Random Effects Model: v(i,t) = e(i,t) + u(i)     |
| Estimates:  Var[e]              =   .258488D+02  |
|             Var[u]              =   .187616D+02  |
|             Corr[v(i,t),v(i,s)] =   .420566      |
| Lagrange Multiplier Test vs. Model (3) =   20.08 |
| ( 1 df, prob value =  .000007)                   |
| (High values of LM favor FEM/REM over CR model.) |
| Fixed vs. Random Effects (Hausman)     =   73.79 |
| (10 df, prob value =  .000000)                   |
| (High (low) values of H favor FEM (REM).)        |
| Reestimated using GLS coefficients:              |
| Estimates:  Var[e]              =   .329910D+02  |
|             Var[u]              =   .361835D+02  |
|             Sum of Squares          .114521D+05  |
+--------------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
LGDP	-5.282891664	1.1047426	-4.782	.0000	7.4156089
INV	.1300376977	.58059783E-01	2.240	.0251	23.062716
LPCI	-3.715983831	.69880544	-5.318	.0000	1.6304444
PRLIB	.9786539280	1.1490308	.852	.3944	2.7804444
PRC	-9.668695251	1.5160985	-6.377	.0000	.83155556E-01
FTLIB	3.072005750	.85172881	3.607	.0003	3.1857778
FTC	-1.042014226	1.2143986	-.858	.3909	.13751111
LSPRIV	-.1602797963	.82242424	-.195	.8455	2.4586667
LSC	1.041954148	1.2688316	.821	.4115	.14551111
ENTC	-3.257174962	1.3195801	-2.468	.0136	.10457778
Constant	30.05783960	8.7047770	3.453	.0006	

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

```
+----------------------------------------------------------------------+
| Least Squares with Group Dummy Variables and Period Effects           |
| Ordinary    least squares regression    Weighting variable = none     |
| Dep. var. = GDP      Mean=  -1.210666667    , S.D.=    9.746467858    |
| Model size: Observations =     225, Parameters =  44, Deg.Fr.=    181 |
| Residuals:  Sum of squares= 4181.845117    , Std.Dev.=        4.80667 |
| Fit:        R-squared=  .803472, Adjusted R-squared =          .75678 |
| Model test: F[ 43,    181] =   17.21,    Prob value =          .00000 |
| Diagnostic: Log-L =   -648.0320, Restricted(b=0) Log-L =    -831.0637 |
|             LogAmemiyaPrCrt.=    3.319, Akaike Info. Crt.=      6.151 |
| Estd. Autocorrelation of e(i,t)     .171994                           |
+----------------------------------------------------------------------+
```

Variable	Coefficient	Standard Error	t-ratio	P[|T|>t]	Mean of X
LGDP	-31.54844603	3.1637354	-9.972	.0000	7.4156089
INV	.3280956325	.62701704E-01	5.233	.0000	23.062716
LPCI	-2.538835274	.82258999	-3.086	.0023	1.6304444
PRLIB	-3.893751020	1.4026256	-2.776	.0060	2.7804444
PRC	-2.902224182	1.6489006	-1.760	.0798	.83155556E-01
FTLIB	2.070572872	.92928555	2.228	.0269	3.1857778
FTC	-1.990506473	1.2159162	-1.637	.1031	.13751111
LSPRIV	-1.266792643	1.0828666	-1.170	.2434	2.4586667
LSC	1.960103819	1.3353781	1.468	.1436	.14551111
ENTC	-2.610989867	1.2965337	-2.014	.0453	.10457778
Constant	237.1604054	24.503564	9.679	.0000	

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

Test Statistics for the Classical Model

Model	Log-Likelihood	Sum of Squares	R-squared
(1) Constant term only	-831.06367	.2127857440D+05	.0000000
(2) Group effects only	-812.15299	.1798621621D+05	.1547264
(3) X - variables only	-740.89342	.9546621932D+04	.5513505
(4) X and group effects	-666.11969	.4911267184D+04	.7691919
(5) X ind.&time effects	-648.03201	.4181845117D+04	.8034716

Hypothesis Tests

	Likelihood Ratio Test			F Tests			
	Chi-squared	d.f.	Prob.	F	num.	denom.	Prob value
(2) vs (1)	37.821	24	.03616	1.525	24	200	.06237
(3) vs (1)	180.340	10	.00000	26.299	10	214	.00000
(4) vs (1)	329.888	34	.00000	18.623	34	190	.00000
(4) vs (2)	292.067	10	.00000	50.582	10	190	.00000
(4) vs (3)	149.547	24	.00000	7.472	24	190	.00000
(5) vs (4)	36.175	9	.00004	3.508	9	181	.00050
(5) vs (3)	185.723	34	.00000	6.829	34	181	.00000

```
+--------------------------------------------------------+
| Random Effects Model: v(i,t) = e(i,t) + u(i) + w(t)   |
| Estimates:  Var[e]              =   .231041D+02        |
|             Var[u]              =   .672266D+03        |
|             Corr[v(i,t),v(i,s)] =   .966774            |
|             Var[w]              =   .403829D+02        |
|             Corr[v(i,t),v(j,t)] =   .636081            |
| Lagrange Multiplier Test vs. Model (3) =   20.21       |
| ( 2 df, prob value =  .000041)                         |
| (High values of LM favor FEM/REM over CR model.)       |
| Fixed vs. Random Effects (Hausman)     =   53.40       |
| (10 df, prob value =  .000000)                         |
| (High (low) values of H favor FEM (REM).)              |
| Reestimated using GLS coefficients:                    |
| Estimates:  Var[e]              =   .310031D+02        |
|             Var[u]              =   .207650D+03        |
|             Var[w]              =   .142558D+03        |
|             Sum of Squares          .317644D+05        |
+--------------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 LGDP      -13.86235169       1.9606428    -7.070   .0000     7.4156089
 INV        .1969442841   .59891121E-01     3.288   .0010     23.062716
 LPCI      -3.379845814       .80733819    -4.186   .0000     1.6304444
 PRLIB     -1.977786851       1.3588494    -1.455   .1455     2.7804444
 PRC       -6.685562168       1.5639529    -4.275   .0000  .83155556E-01
 FTLIB      3.581694927       .89972310     3.981   .0001     3.1857778
 FTC       -1.664708430       1.2124241    -1.373   .1697     .13751111
 LSPRIV    -1.355271172       1.0283715    -1.318   .1875     2.4586667
 LSC        1.573684913       1.3183963     1.194   .2326     .14551111
 ENTC      -2.992079377       1.2928991    -2.314   .0207     .10457778
 Constant   100.0999933       16.426378     6.094   .0000
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
```

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